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Optical Heterogeneity of Feldspars Observed in Diverse Canadian Rocks

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With 3 plates and 1 table

Abstract

Nearly one thousand Canadian rocks examined in thin sections are found to contain heterogeneous feldspars. Nine types of heterogeneity and five morphological types of alteration are distinguished and described. Distinctions are made on the basis of optical heterogeneity, and corresponding variations in chemical composition have been confirmed by chemical tests on a few samples. Occurrence and distribution of these feldspars in 200 rocks of diverse age, origin and type are summarized. Heterogeneity may result from environmental changes during crystal growth or from subsequent migration of ions. Migration of ions may be recognized from a study of heterogeneous feldspars and is particularly important for evaluation of chemical analyses and trace element studies.

INTRODUCTION

Several authors have described various submicroscopic to macroscopic heterogeneities in feldspars, and discussed their genetic significance. Thus, Emmons et al. (1953) point out the significance of optical irregularities: zones, twins, inclusions, perthites, mottling, and alterations, for studies of the relationship between optical properties and chemical composition of feldspars, and discuss their petrogenesis. Laves (1956) describes a zonal structure and displacive transformation in feldspars; Bambauer and Laves (1960), and Laves, Nissen and Bollmann (1965) discuss lamellar structure of zoned adularia and of labradorites; Laves and Soldatos (1963) present examples of unmixing, recrystallization and replacement phenomena in microcline perthites and in poikilitic feldspars. Deicha (1961) discusses the significance of cavities and inclu-

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sions in feldspars. Augustithis (1962) gives examples of non-eutectic graphic intergrowths between feldspars and other minerals.

In attempting a mineralogical, petrological and petrochemical correlation of about one thousand diverse Canadian rocks the present writer was impressed with the need for a comprehensive summary of the types of heterogeneities that occur in relatively fresh feldspars in common rocks. The present paper describes the principal features of heterogeneous feldspars that have been observed optically and discusses their distribution in about 200 rocks.

Thin sections used in the present study were randomly selected from about one thousand rocks collected by field geologists for K/Ar age determination by the Geological Survey of Canada. It is important to point out that most of the rocks were chosen to represent characteristic and widespread petrological units and to be as free from weathering as possible.

TYPES OF HETEROGENEOUS FELDSPARS

In order to compare feldspars in diverse rocks, the following nine principal types of optical heterogeneity have been distinguished:

I Compositional zoning: Plate I, Figs. I-1, I-2, I-3.
II Lamellar intergrowths: Plate I, Figs. II-4, II-5, II-6.
III Perthites and antiperthites: Plate I, Figs. III-7, III-8, III-9.
IV Poikilitic feldspars and feldspars with inclusions: Plate II, Figs. IV-10, IV-11, IV-12.
V Composite and patchy feldspars: Plate II, Figs. V-13, V-14, V-15.
VI Graphic intergrowths: Plate II, Figs. VI-16, VI-17, VI-18.
VII Replacement feldspars, thin coatings: Plate III, Figs. VII-19, VII-20, VII-21, and Plate II, Fig. IV-11.
VIII Discontinuous twinning: Plate III, Figs. VIII-22, VIII-23, VIII-24.
IX Cataclastic and fractured feldspars: Plate III, Figs. IX-25, IX-26, IX-27.

These main types of heterogeneity have been further subdivided on the basis of degree and type of alteration and on the basis of chemical composition of the feldspar. Symbols are used for descriptive coding, for example: altered (A), fresh (F), plagioclase (P), potassium feldspar (K), and molecular proportion anorthite (An_{45}). In addition, five morphological features of alteration products have been noted and designated as follows:

A-1 Central portion (1 c) or local patch of feldspar replaced by secondary minerals: Plate I, Fig. I-2; Plate II, Fig. IV-12.

A-2 Alteration along alternating zones: Plate I, Fig. I-3.

A-3 Alteration along twin directions or selective alteration of twin components: Plate I, Fig. II-6.

A-4 Alteration along cleavage planes and/or fractures: Plate III, Fig. IX-25.

A-5 Replacement at grain boundaries by fibrous aggragates: Plate II, Fig. VI-18.

Common secondary minerals and their abbreviations are: alkali feldspar (Alk), apatite (Ap), biotite (B), carbonate (Cb), chlorite (ch), epidote (Ep), iron oxides (Fe), potassium feldspar (K), muscovite (M), microcline (Mi), opaque minerals (Op), quartz (Q), sericite (Sc), and small specks $< 1\ \mu$ diameter (Sp). Thus the feldspar illustrated in Plate I, Fig. I-1, would be recorded as *I: FP*, An_{44-23}; *5% AP, 1 c-M, 4-Op, M* to indicate that it is zoned plagioclase of molecular proportions An_{44} to An_{23}, and about five per cent of its area is altered to muscovite in the centre and to muscovite and opaque minerals along fractures.

OBSERVATIONS ON TYPES OF HETEROGENEITY

I. Compositional Zoning. Zoned plagioclases varying in composition from bytownite to albite, and from andesine to albite were observed in diabase, gabbro, granodiorite, quartz monzonite, granite, and in their metamorphic equivalents. Characteristic alterations of zoned feldspars are: completely to partly altered central portions (type 1 c, Fig. I-2) and altered zones (type 2, Fig. I-3). The secondary minerals may be the same in all zones, or differ from zone to zone, for example, microcline in the centre, surrounded by a zone consisting predominantly of epidote, which in turn is surrounded by a zone of sericite. A few zoned potassium feldspars were also observed. They are composed of concentric perthitic zones that differ in size and density of the albite component, and are separated by bands of quartz inclusions. These feldspars, however, are better assigned to the related type V, composite-patchy feldspars.

II. Lamellar Intergrowths. Lamellar plagioclases that consist of parallel intergrowths of plagioclases ranging in composition from An_{70} to An_5, with and without narrow lamellae of potassium feldspar (Fig. II-5), are common in basic rocks, and have been studied by means of an electron probe microanalyser (Rimsaite and Lachance, 1966). A related type (II K) consists of plagioclase that is uniform in chemical composition and contains parallel narrow bands (*ca* 3 μ in width) of potassium feldspar (Fig. II-4). This type of feldspar was observed most frequently in gneisses that contain very little potassium feldspar. In such gneisses, almost the entire potassium feldspar content is present in the form of narrow lamellae in the plagioclase. The lamellae of potassium feldspar are frequently affected by alteration. When partly resorbed and replaced by sericite, the remaining potassium feldspar forms skeletal net-like aggregates. The plagioclase of this type of lamellar intergrowths (Fig. II-6) has been designated *II Kn*. Some of the lamellar feldspars form as a result of alteration; the skeletal type (II Kn) particularly indicates post-crystallizational alteration. The reasonably fresh crystals observed in basic rocks, however, probably formed during primary crystallization of the feldspar. In many rocks potassium feldspar lamellae cannot be observed, but their presence in the original feldspar may be inferred from a lamellar arrangement of alteration products. Labradorites with submicroscopic lamellar structure have been studied by means of electron microscope and X-ray diffraction techniques by Laves, Nissen and Bollmann (1965) who have discussed several hypotheses for their origin.

III. Perthites and Antiperthites. Numerous sub-groups were distinguished on the basis of size, shape and origin, following Alling (1932), on the basis of density and distribution within the host (Fig. III-7, also Rimsaite and Lachance, 1966), and on the basis of associated minerals (Figs. III-8 and 9). All Grenville anorthosites from Northern Quebec examined by the writer contained antiperthitic andesine-labradorite. Anorthosite from Manitoba (2435 m.y. old) is composed mainly of lamellar plagioclase, and anorthosites from Newfoundland are cataclastic, slightly antiperthitic, and severely altered. In anorthosites from Quebec, the potassium component of antiperthites is frequently replaced by muscovite (Rimsaite, 1964, Fig. 2, p. 165) and/or biotite. The muscovite appears to be pseudo-morphous after potassium feldspar while biotite is formed in place of opaque specks and potassium feldspar. Examples were observed of oriented inclusions of biotite and muscovite with or without opaque grains and blebs of potassium feldspar. Perthites and antiperthites show a distinct preference in local distribution. They are of frequent occurrence in rocks of Northern Quebec, and are found mainly in anorthosites, quartz monzonites, granites and in their metamorphic equivalents.

IV. Poikilitic Feldspars and Feldspars with Inclusions. Three sub-groups were distinguished: a) poikilitic feldspars which form as a result of a preferential growth of a mineral that engulfs and encloses previously formed or slower growing minerals (Fig. IV-10). Further distinction may be made on the basis of degree of alteration and resorption of the enclosed mineral; b) feldspars containing coarse inclusions of other minerals or feldspar varieties which are formed probably as a result of replacement (Fig. IV-12), and c) feldspars containing numerous inclusions of uncertain origin, such as numerous apatite needles (common in plagioclases from basic rocks), relatively coarse euhedral crystals of apatite and epidote, coarse-grained micas, quartz (Fig. IV-11), and other ferromagnesian minerals. Poikilitic feldspars occur most frequently in metamorphic rocks. The host mineral or the inclusion or both can be affected by alteration. Haloes surrounding inclusions and myrmekitic plagioclases are very common in microcline (Fig. IV-11).

V. Composite-Patchy Feldspars. Composite feldspars are related to poikilitic and to zoned feldspars. They are formed as a result of interruptions during growth, frequently accompanied by resorption. Several sub-groups were distinguished:

a) Composite plagioclases with albite rims, showing signs of resorption (Fig. V-13).
b) Composite microcline with enclosed patches of plagioclase (Fig. V-14).
c) Several deformed grains of plagioclase (a composite centre) overgrown by zoned plagioclase (Fig. V-15). Feldspars of this group exhibit alterations common to zoned feldspars and a patchy alteration that affects either some or all of the components. The group is most common in gneissic rocks and in quartz monzonites.

VI. Graphic Intergrowths. Graphic intergrowths of feldspars with quartz (Fig. VI-16), with muscovite, biotite, chlorite and opaque minerals, and of plagioclase and microcline (Fig. VI-17), occur frequently in pegmatites, gneisses and quartz monzonites. Graphic intergrowths of plagioclase and alkali feldspar are common granophyres and in gabbros (Fig. VI-18). One or both components can be affected by alteration. The edge of micrographic plagioclase (Fig. VI-18) suggests replacement of existing plagioclase by alkali feldspars. A non-eutectic origin of some micrographic textures has been recently discussed by Augustithis (1962).

VII. Replacement, Films and Coatings. Thin films and coatings of potassium feldspar on biotite and along cleavage planes and fractures of plagioclase were observed in many gneisses (Figs. VII-19 and 21). Further-more, coatings of potassium feldspar and albite were frequently observed around inclusions of quartz, apatite, and opaque grains in poikilitic minerals (Fig. VII-20), and in mylonitized areas. Replacement of biotite along grain boundaries and cleavage planes by potassium feldspar is a result of superimposed higher grade metamorphism. Such biotites are commonly found in metamorphic rocks of hornblende grade and show a considerable deficiency of the (OH, F)-group, or dehydration (RIMSAITE, 1964). It is interesting to point out the apparent relationship between the coatings of potassium feldspar around biotite, and thin lamellae of speckled potassium feldspar in adjacent plagioclase (Fig. VII-19). There are two possible explanations for the origin of the potassium feldspar lamellae in plagioclase: (1) potassium is derived from plagioclase by migration of ions and recrystallization, similar to the suggested origin of plate-perthite by LAVES and SOLDATOS (1962), and (2) potassium (and opague specks) were derived from partly decomposed biotite. The presence of potassium feldspar around inclusions of apatite, and in parallel bands of lamellar plagioclase was confirmed by electron microprobe analysis (RIMSAITE and LACHANCE, 1966).

VIII. Discontinuous Twinning. Discontinuity in twinning, and in size and distribution of blebs in perthites and antiperthites was observed in feldspars from pegmatites, quartz monzonites and gneisses (Figs. VIII-22 to 24). The fine-perthitic, coarse-perthitic and non-perthitic, twinned, and untwinned portions of the microcline crystal were separated in heavy liquids. The differences in specific gravity between the various phases clearly indicate variations in chemical composition. Segregation of small particles into larger ones in perthites was observed and attributed to secondary recrystallization by LAVES and SOLDATOS (1963). Partly twinned and partly perthitic (antiperthitic) feldspars were found mainly in rocks affected by metamorphism. Perthitic cores and non-perthitic rims are common.

IX. Cataclastic and Fractured Feldspars. Cataclastic and fractured feldspars were distinguished on the basis of bent twinning lamellae, wavy extinction, and inclusions (Fig. IX-26). Cataclastic feldspars are heterogeneous as a result of introduced foreign material into fractures. Some of these feldspars are in part recrystallized, but veinlets and inclusions of foreign minerals, such as quartz, calcite, iron oxides and micas, remain as relics of impurities in fractures. The most striking examples are provided by fractured feldspars that surround radioactive minerals (Fig. IX-25). The fractures are coated with hematite and other oxides derived from radioactive minerals even in areas where no radioactive minerals could be observed (RIMSAITE and LACHANCE, 1966). Some cataclastic feldspars are severely affected by alteration, and the only clear portions are bands along the fractures (Fig. IX-27) which suggest leaching of secondary minerals and probably some decomposition of the host along the fracture.

All rocks contain altered areas, and the feldspars as well as other minerals are altered locally. The degree of feldspar alteration in the thin section may vary from a few percent of the total feldspar area to complete alteration. Plagioclase is usually more altered and fractured than potassium feldspar, which in many rocks forms later than plagioclase. Alteration of feldspar (plagioclase) can be correlated with the alteration of biotite.

A compilation of the observed nature and distribution of optically heterogeneous feldspars in 200 Canadian rocks is given in Table I, as a preliminary step in a larger scale correlation of the mineralogical features of common rocks. For each rock type, the locations, alteration products, and ranges in age, composition of plagioclase and percentage of alteration are noted. In the main body of the table, the types of heterogeneity and alteration are listed and the percentage is given of individual rocks within a given rock type found to contain that type of heterogeneity or alteration. It should be noted that most rocks contain more than one type of heterogeneous feldspars. Thus, the first line of Table I indicates that 26 per cent of the diabases examined contained heterogeneous plagioclase of type I (compositional zoning); 35 per cent showed lamellar intergrowths of type II, etc. On the basis of this preliminary compilation, the following generalities may be made regarding the occurrences of the various types of heterogeneous feldspars and their alterations:

1. Compositional zoning is common in diabase, gabbro, granodiorite and quartz monzonite and the gneissic equivalents of the latter two; it is rare or absent in anorthosite, granite, pegmatite, gneiss, paragneiss and schist.

2. Lamellar feldspars consisting of intergrowths of chemically different plagioclase and potassium feldspar occur mainly in diabases and gabbros, and in some anorthosites. Lamellar intergrowths of plagioclase of uniform composition with narrow lamellae of fresh (II K) or altered potassium feldspar (II Kn) are common in gneisses.

3. Antiperthites were observed in most of the anorthosites examined. Perthites and antiperthites are particularly abundant in granites, pegmatites and gneisses of Northern Quebec.

4. Poikilitic feldspars are common to all rocks and are especially abundant in metamorphic rocks.

5. Composite and patchy feldspars are common in gneissic granite, granodiorite and quartz monzonite, less common in the igneous equivalents, and relatively rare or absent in paragneiss, schist, diabase, gabbro and anorthosite.

6. Graphic intergrowths occur most frequently in gabbro, quartz monzonite, pegmatite and in gneissic granite and quartz monzonite.

7. Replacement potassium feldspars are found in all rocks and are particularly abundant in gneiss, granite gneiss, anorthosite, paragneiss and schist.

8. Discontinuous twinning has not been observed in the basic rocks, diabase and gabbro. It is most common in granite gneiss and pegmatite.

9. Cataclastic feldspars are most common in metamorphic rocks.

10. Some types of alteration are related to a particular type of feldspar, for example, altered centres (1 c) and zones (2), and fibrous alteration (5) are found in zoned and in calcic plagioclases, respectively. The other types, such as alteration along twinning and cleavage planes, and along fractures are common to all, particularly to cataclastic feldspars. Sericite is the most common alteration product, followed by unidentified small specks and epidote.

Recognition and study of heterogeneous feldspars is essential to a proper evaluation of rock analyses and may be important in the interpretation of isotopic ages. More detailed studies should yield important information on the introduction and migration of ions during various geological processes of alteration. In the broader field of petrology, it is hoped that an extension of this work will prove useful for correlation of rocks geographically and through petrological changes.

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PLATE I

Fig. I-1. Zoned plagioclase (I : FP), An_{44-23}, with central portion altered to muscovite and fractures filled with mica and opaque grains (5% AP, 1c-M, 4-Op, M). Granodiorite, British Columbia, 56 m.y. x50; +N.

Fig. I-2. Zoned plagioclase (I : FP) with a clear rim, altered to epidote (centre) and sericite (zone surrounding epidote) (50% AP, 1c-Ep, Sc). Granodiorite, Quebec, 2670 m.y. x50; +N.

Fig. I-3. Zoned plagioclase (I : FP) with central portion partly replaced by microcline (white patch), epidote and sericite (80% AP, 1c-Mi, Ep, Sc), and with alternating zones altered to sericite (10% AP, 2-Sc). Gneissic granite, x50; +N.

Fig. II-4. Lamellar feldspar. Bands of potassium feldspar in plagioclase (IIK; FP). Paragneiss, Manitoba, 1700 m.y. x500.

Fig. II-5. Lamellar plagioclase, An_{70-5}, with narrow bands (*ca* 3 μ) of potassium feldspar parallel to plagioclase twinning (IIK : FP, An_{70-5}). Ophitic gabbro, Ontario, 1925 m.y. x500; +N.

Fig. II-6. Lamellar plagioclase (IIKn : FP) with potassium feldspar bands partly resorbed and replaced by sericite. Potassium feldspar and sericite occur as net-like aggregates (15% AP, 3, 4-Sc, Kn). Migmatite, District of Mackenzie, 2465 m.y. x100.

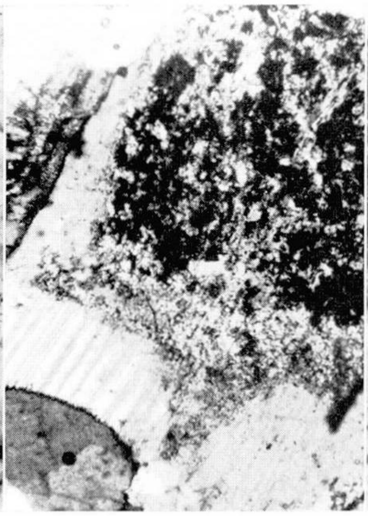
Fig. III-7. Antiperthitic andesine, An_{45}, with disseminated opaque specks, showing irregular distribution of potassium feldspar: dense accumulation (IIIa : FPK), left, and roughly parallel rows of small specks (IIIc : FPK), right. Anorthosite, Quebec, 805 m.y. x500.

Fig. III-8. Antiperthitic labradorite with opaque grains along and across inclusions of potassium feldspar. (IIIOp : FPK). Anorthosite, Quebec, 805 m.y. x500.

Fig. III-9. Microcline perthite with biotite flakes transecting plagioclase blebs (IIIB : FKP). Granite, District of Mackenzie, 2100 m.y. x500.

PLATE I


I-I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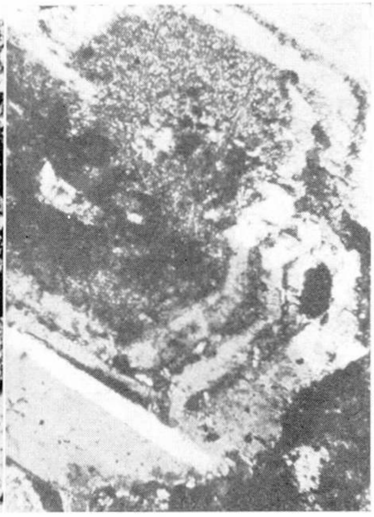
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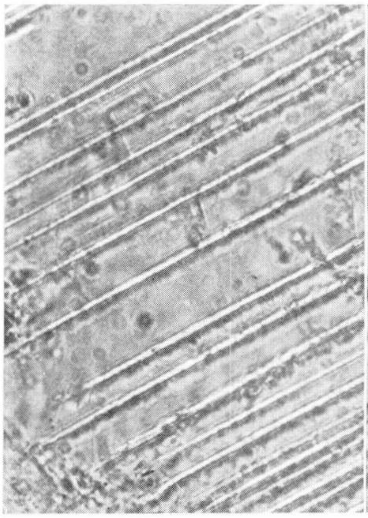
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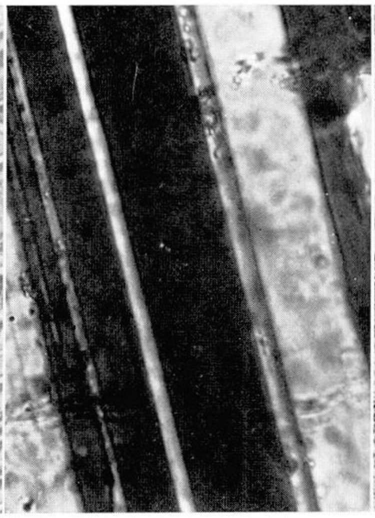
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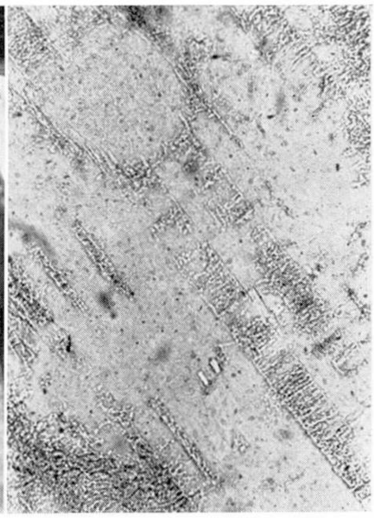
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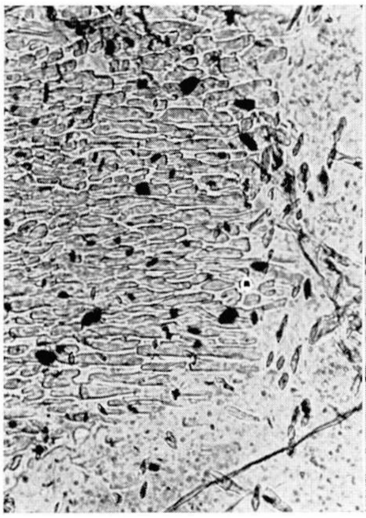
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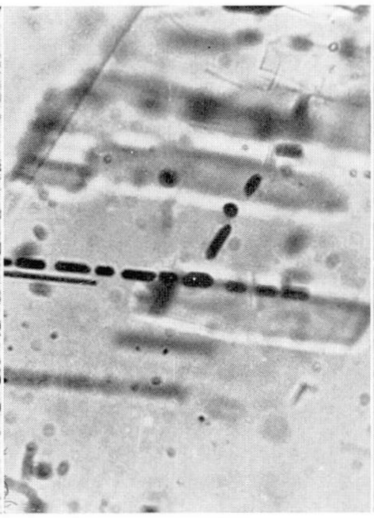
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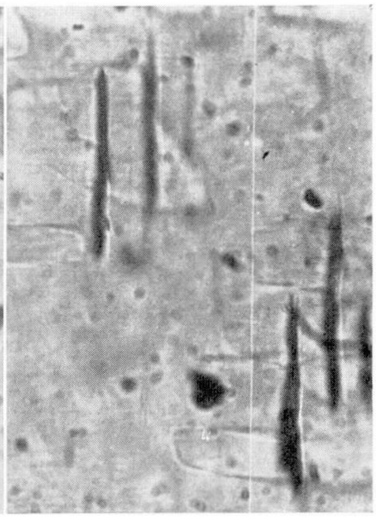

III-9

PLATE II

Fig. IV-10. Poikilitic microcline with subhedral inclusions of zoned, altered plagioclase (IVPa : FK). Gneissic granite; x50; +N.

Fig. IV-11. Poikilitic microcline with inclusion of quartz (black). Quartz is surrounded by a halo of plagioclase (IVQ, P : FK). Granitic gneiss, Manitoba, 1655 m.y. x50; +N.

Fig. IV-12. Poikilitic plagioclase with inclusions of microcline (IVK : FP). The plagioclase is slightly antiperthitic and contains a few patches altered to sericite. Quartz monzonite, District of Mackenzie, 2555 m.y. x100; +N.

Fig. V-13. Composite-patchy plagioclase, exhibiting phenomena of resorption and further growth, rimmed with albite (V : FP). Anorthositic gabbro, Mount Megantic, Quebec, 126 m.y. x50; +N.

Fig. V-14. Composite microcline with patches of plagioclase (VP : FK). Quartz monzonite, District of Mackenzie, 2450 m.y. x500; +N.

Fig. V-15. Zoned plagioclase (I : FP) with a composite-patchy core (V : FP). Some zones are slightly altered to sericite (5% AP, 2-Sc). Granodiorite, Manitoba, 2670 m.y. x50; +N.

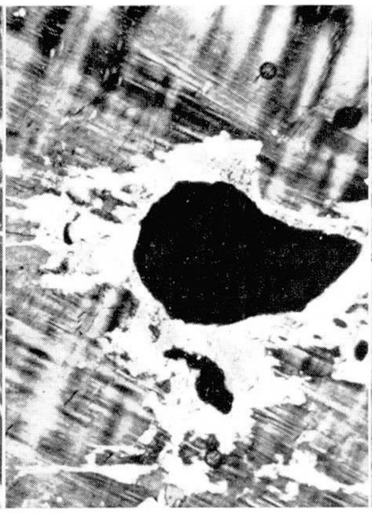
Fig. VI-16. Graphic intergrowths of quartz and albite (VIQ : FP) at the contact with microcline perthite (IIIP : FK). Myrmekite contains a patch of microcline (right, upper field). Quartz monzonite, District of Mackenzie, 2540 m.y. x500; +N.

Fig. VI-17. Graphic intergrowths of plagioclase and microcline (VIK : FP). Hornblende biotite gneiss; x500; +N.

Fig. VI-18. Plagioclase laths partly replaced by alkali feldspar. Graphic intergrowths of labradorite-andesine and alkali feldspar (VIAlk : FP). Alkali feldspar in the groundmass is clouded by small specks (80% AAlk, 1-Sp), and the plagioclase is partly replaced by fibrous aggregates (40% AP, 5-Ep, Cb, Sp). Granophyre, Ontario, 1000 m.y. x100.

PLATE II

IV-10



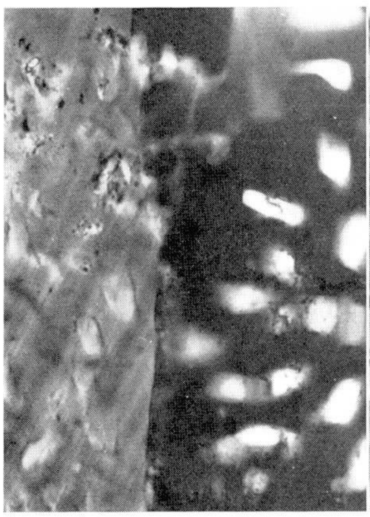
IV-11

IV-12

V-13

V-14

V-15



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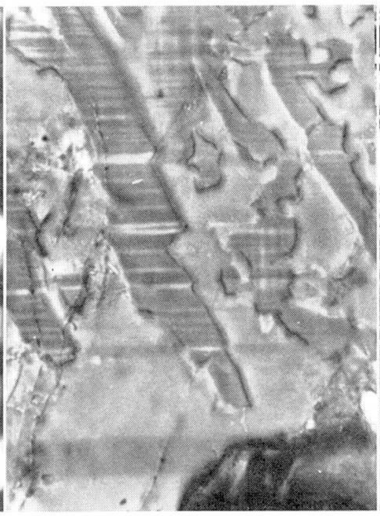


VI-17

VI-18

PLATE III

Fig. VII-19. Narrow parallel bands of potassium feldspar in plagioclase (VII P : FK), and coatings along biotite edges (VII B : FK); white band of potassium feldspar is prominent in the upper right field. Hornblende biotite gneiss; x 500.

Fig. VII-20. Antiperthite with inclusions of apatite surrounded by potassium feldspar. Granite gneiss, District of Mackenzie, 1830 m.y. x 100.

Fig. VII-21. Biotite with a narrow band of potassium feldspar (K) along the boundary (low relief, from centre, right). Garnet gneiss; x 500.

Fig. VIII-22. Discontinuous twinning and local concentrations of vein perthite in microcline (III P, VIII : FK). Quartz monzonite; x 50; +N.

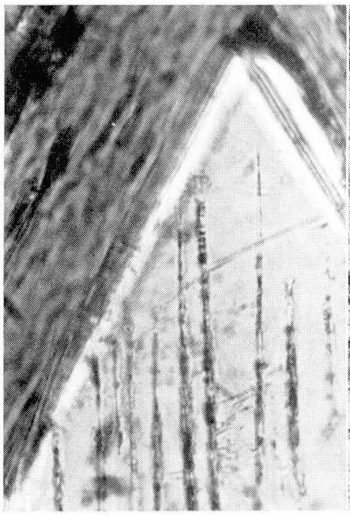
Fig. VIII-23. Microcline perthite with fine and coarse blebs of plagioclase, and with scattered opaque inclusions (III P f and c, VIII : FK). Granite, District of Mackenzie, 2100 m.y. x 500.

Fig. VIII-24. Discontinuous twinning in microcline perthite. Areas containing rare, coarse plagioclase blebs are twinned, whereas areas with dense concentration of small plagioclase specks are optically untwinned (III P f and c, VIII : FK). Granite, District of Mackenzie, 2100 m.y. x 500; +N.

Fig. IX-25. Cataclastic, fractured feldspar (IX : FP) around radioactive crystals of uraninite. Fractures are filled and coated with hematite and other oxides. Radioactive ore-body, Ontario; x 50.

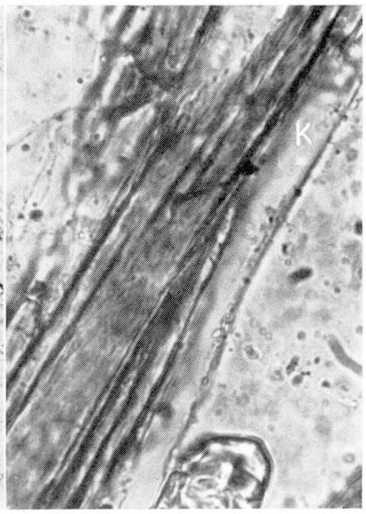
Fig. IX-26. Cataclastic and fractured antiperthite exhibiting wavy extinction. Twinning lamellae (left) and roughly parallel rows of potassium feldspar blebs are bent. Garnet gneiss; x 100; +N.

Fig. IX-27. Speckled antiperthitic albite with clean bands along fractures and clean spots of potassium feldspar blebs and patches (80% AP, 1 cf-Sp). Pegmatitic feldspar; x 100.



VII-19

VII-20



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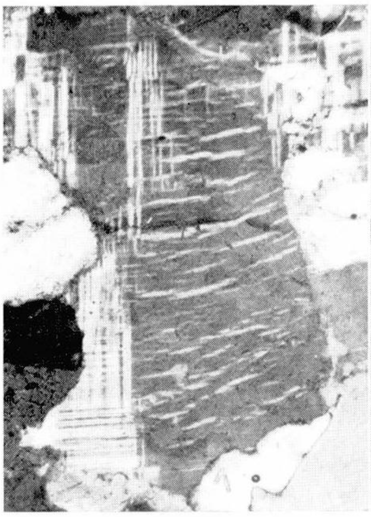
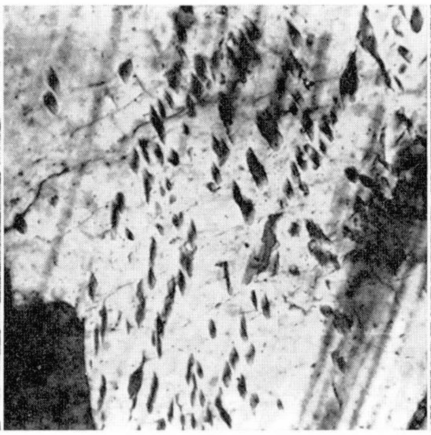


VIII-22

VIII-23

VIII-24

IX-25



IX-26

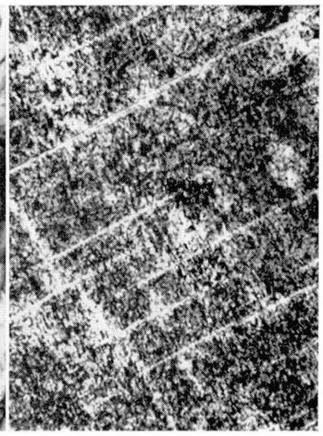


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Table I. *Distribution of Optically Heterogeneous Feldspars in 200 Canadian Rocks*

Rock Type	Sample Locality, Province *)	K/Ar Age m. y. **)	Composition of Plagioclase An %	Common alteration products	Variation in estimated area of alteration	Type of Heterogeneous Feldspar																							
						Plagioclase											Potassium Feldspar							Alteration					
						I	II	IIK	IIKn	III	IV	V	VI	VII	VIII	IX	III	IV	V	VI	VII	VIII	IX	1c	1	2	3	4	5
Diabase	O, M, DM	750—2095	75—5	Ap, Ep, Cb, Ch, Op, Sc, Sp	10—100	26	35	30	—	10	50	—	—	—	—	—	—	—	—	—	40	—	—	40	40	—	25	50	50
Gabbro	Q, O, DF	126—1240	70—5	Ap, Cb, Ep, Op, Sc, Sp	10—80	35	20	19	—	—	21	7	49	—	—	—	—	—	—	—	35	—	—	30	60	—	70	70	42
Anorthosite	Northern Q	805—955	54—46	B, M, Op	5—50	—	—	15	15	100	—	—	—	—	—	40	—	—	—	—	70	—	—	—	50	—	90	80	—
	Q, NFL, M	451—2435		Ep, Q, Sc, Sp	5—80	5	5	20	15	75	10	—	—	—	5	50	—	—	—	—	70	—	—	—	60	—	90	85	—
Granodiorite	Q, O, DM, BC	56—2605	44—5	Ep, M, Sc, Sp	5—80	36	—	6	6	18	18	30	18	—	24	6	12	18	—	—	12	18	—	20	34	—	36	24	—
Quartz Monzonite	M, S, DM DK, BC	18—2555	30—5	B, Ep, M, Sc, Sp	5—80	24	—	24	30	48	48	35	48	—	42	30	66	66	18	—	48	42	12	10	80	20	96	30	—
Granite	NFL, NS, NB, Q, O, DM	383—2490	20—5	B, Cb, Ch, Ep, M, Sc, Sp	5—70	5	—	15	10	30	20	15	15	5	10	15	35	20	5	—	35	15	20	15	30	20	40	10	—
Pegmatite	Q, O, M, S	1000—2560	15—5	Ap, B, M, Op, Sc, Sp	5—85	—	—	—	—	12	60	20	60	—	36	24	48	60	—	60	—	60	—	—	60	—	48	48	—
Gneissic Granodiorite	Q, O, M, DK, DM	1075—3300	30—5	B, Cb, Ep, M, Sc, Sp	5—60	48	—	—	16	40	96	48	64	—	48	40	28	64	—	—	32	12	12	28	56	7	42	56	—
Granite Gneiss	Q, DK, DM	985—1830	25—5	Ep, Sc, Sp	10—70	—	—	10	20	30	80	40	60	—	50	30	60	40	—	—	80	30	20	—	70	—	60	80	—
Hornblende and Augen-Gneiss	Q, O, DM	940—1945	35—5	Ap, Ep, Op, Sc, Sp	5—80	5	—	22	12	25	35	28	20	2	32	17	35	30	—	3	35	15	32	10	40	2	32	40	—
Paragneiss	Q, O, S, DM	765—2465	30—5	Ap, Ep, Fe, Sc, Sp	5—100	—	—	28	24	36	44	—	12	—	36	52	16	12	—	—	60	12	8	—	40	—	56	64	4
Gneiss (K < 5 %)	M, S, DK, DM	1590—2135	30—5	Ep, Fe, Op, Sc, Sp	5—100	—	—	60	8	32	40	16	4	—	36	48	—	—	—	4	100	—	—	—	84	—	76	92	4
Schist and Slate	O, M, DM, YT	147—2400	20—5	Ap, Sc, Sp	0—60	—	—	—	45	5	30	5	10	—	25	20	—	10	—	—	50	—	—	—	30	—	35	20	—
Average all Rocks						13	6	25	17	27	38	26	25	2	27	21	25	22	2	3	45	15	12	11	62	2	58	53	6

*) Abbreviations used for the Provinces of Canada: NFL = Newfoundland; NS = Nova Scotia; NB = New Brunswick; Q = Quebec; O = Ontario; M = Manitoba; S = Saskatchewan; DK = District of Keewatin; DM = District of Mackenzie; BC = British Columbia; YT = Yukon Territory.

**) K/Ar ages taken from: Reports on isotopic ages by the Geological Survey of Canada, compiled by LOWDON, J. A., 1961, 1962, 1963. Geological Survey of Canada, Paper No. 61—17; 62—17; 63—17.