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GEOLOGY OF THE NORTHERN LEWIS HILLS, WESTERN NEWFOUNDLAND

by

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A Dissertation

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the Requirements for the Degree of

Doctor of Philosophy

College of Arts and Sciences

Department of Geological Sciences

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"Transformed individuals make a transformed world"

-Celestial Seasonings Red Zinger Tea tag line-

Frontispiece : Ultramafic rocks (gold) of the northern Lewis Hills are thrust over Humber Arm Supergroup sediments (vegetated lowlands in foreground). Lewis Hill Peak (2673', highest point on the Island of Newfoundland) is on the skyline at the extreme left.

Figure 9 Rocks from The Little Port Assemblage

a. Poikilitic hornblende-gabbro with large hornblende and inclusions of plagioclase; matrix is mainly plagioclase and finer-grained hornblende. b. Diabase with many plagioclase laths, relict hornblende, and sphene with subophitic texture. c. Polished slab of mylonitic quartz-diorite; more deformed at top where there are abundant rounded plagioclase porphyroblasts. d. photomicrograph of less deformed part of the slab in c; quartz is highly recrystallized and biotite films define a weak foliation.

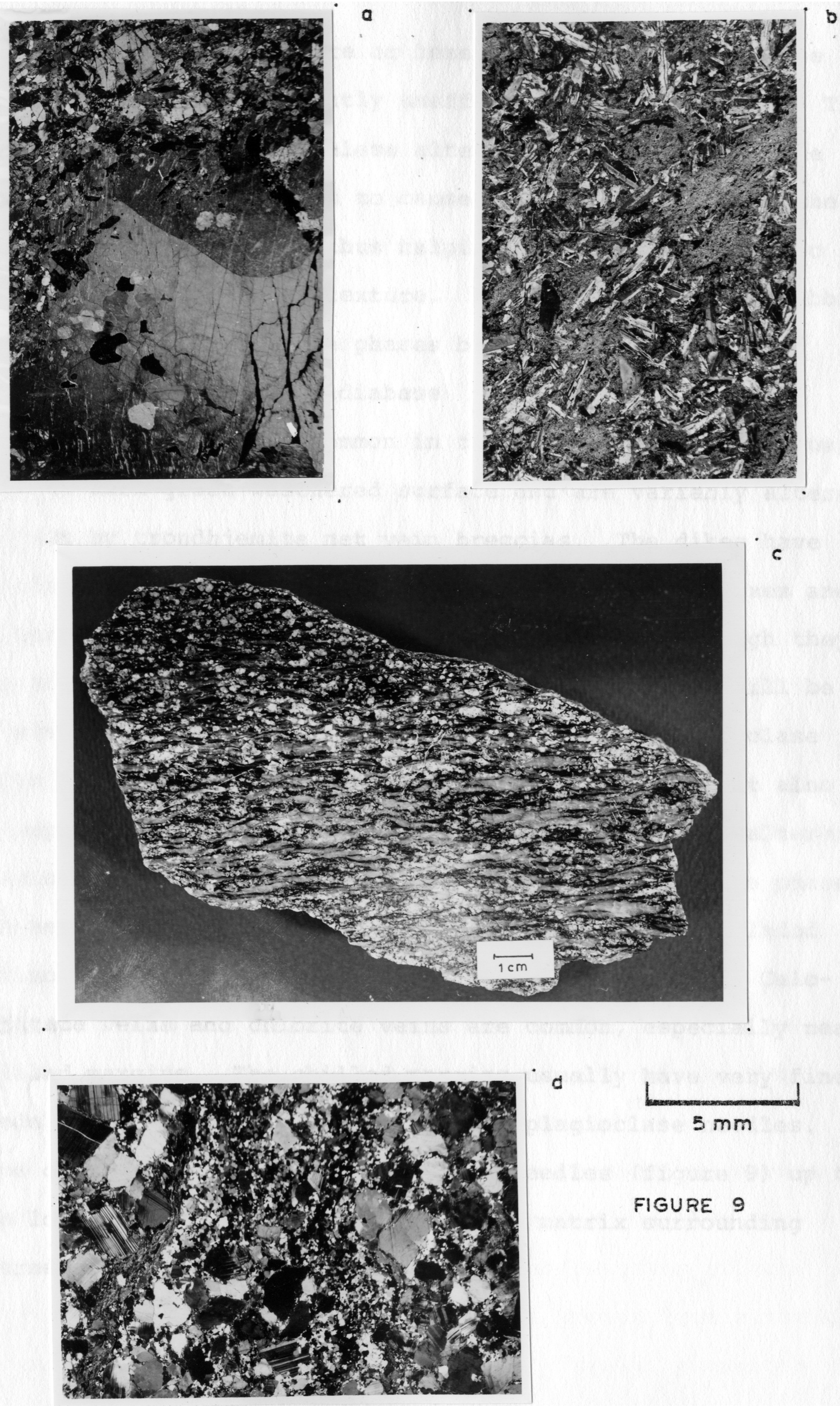
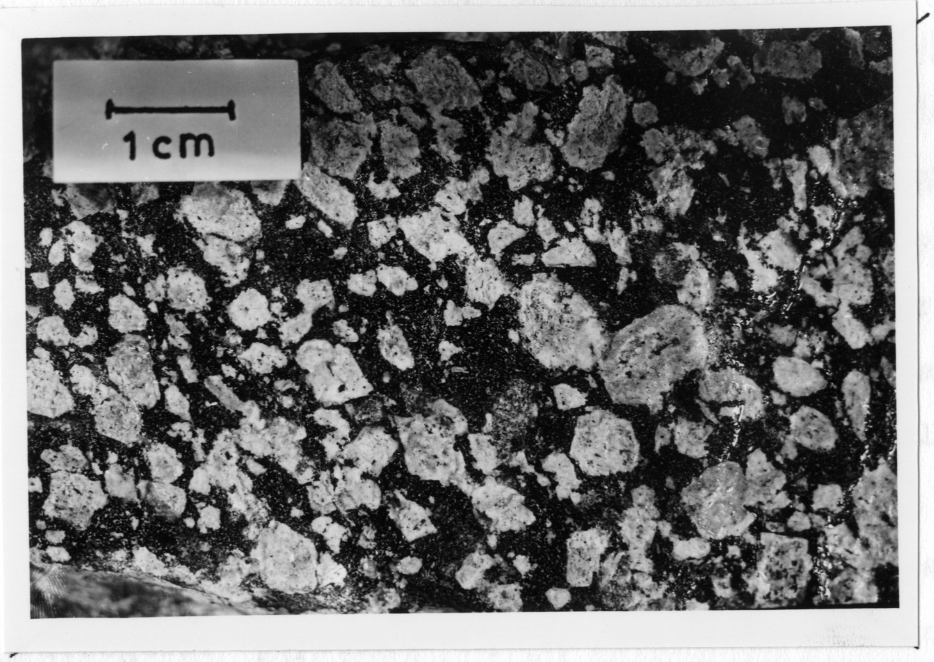


FIGURE 9

Figure 10 Porphyritic Diabase a. weathered surface of porphyritic diabase dike with coarse euhedral to very irregular and fragmental plagioclase phenocrysts in a fine-grained mafic matrix. b. photomicrograph (crossed-nicols) of slab in a showing the well recrystallized matrix of decussate (brown) hornblende and granoblastic plagioclase enclosing complexly twinned, zoned plagioclase phenocrysts; note brittle deformation of phenocrysts. c. same as b except nicols at 60°. d. photomicrograph of mafic sheet in the MBA with plagioclase megacrysts and medium-grained decussate matrix of (red brown) hornblende and plagioclase.

a



b

c

d

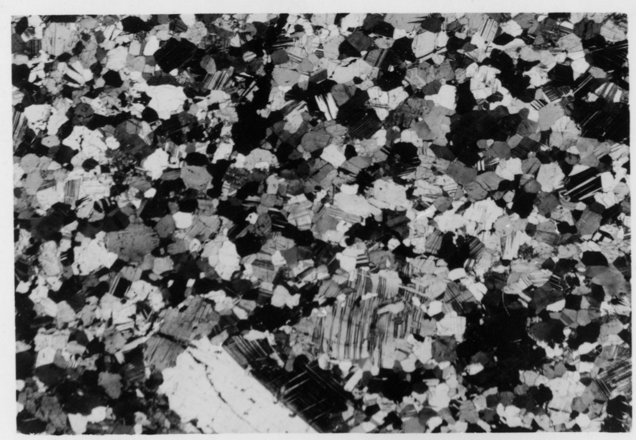


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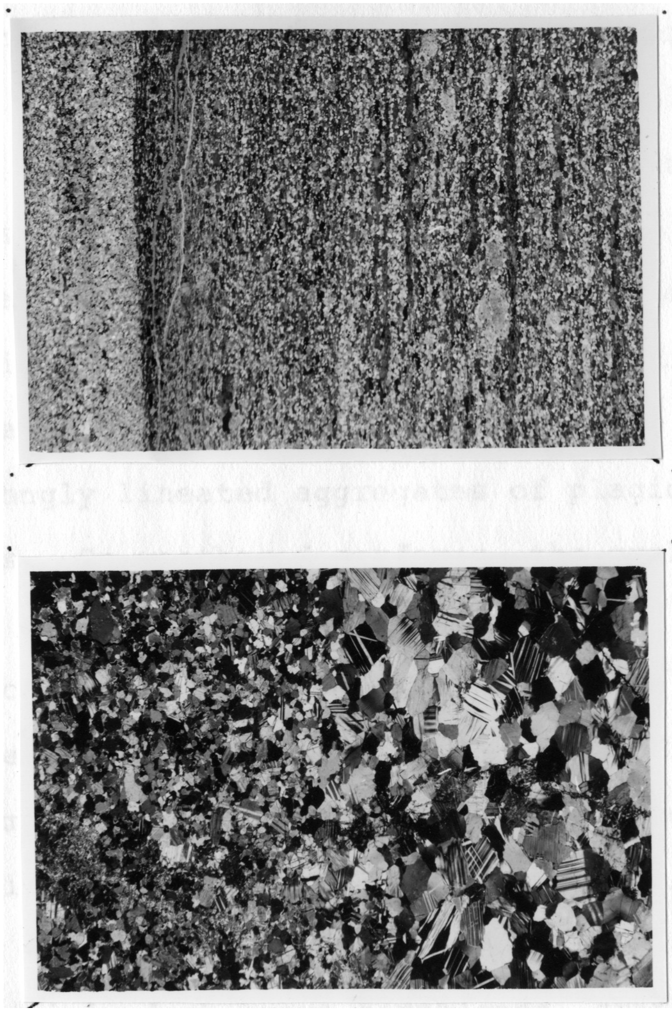
FIGURE 10


a
b

<u>Figure 11</u> Rocks of the MBA a. fine-grained, lineated amphibolite with green hornblende and plagioclase including an augen of pale green, coarse-grained hornblende schist and a band (light) of granoblastic plagioclase, clinopyroxene and opaques. b. well re-crystallized gabbroic gneiss from the migmatite area with coarse-grained anorthosite, finer-grained plagio-clase + clinopyroxene + brown hornblende + opaque gneiss and a thin intervening band of plagioclase + hypersthene gneiss.

Figure 12 Photomicrographs of intrusive ultramafic rocks of the Coastal Complex a. lherzolite with large poikiloblastic, twinned clinopyroxene megacrysts in a highly deformed and serpentinized olivine + enstatite matrix; inclusion in the clinopyroxene are olivine and chromite. b. very highly deformed and serpentinized phacoidal ultramafic rock from the serpentinite mélange c. undeformed feldspathic lherzolite with large, subhedral to rounded olivine and much smaller chromite grains in a matrix of large irregular, optically continuous, poikilitic masses of plagioclase, clinopyroxene, pale red brown amphibole (pargasite) and orthopyroxene; olivine grains include tiny chromite grains. d. interlocking texture in hypersthene + pargasite apophysis of the peridotite pluton.

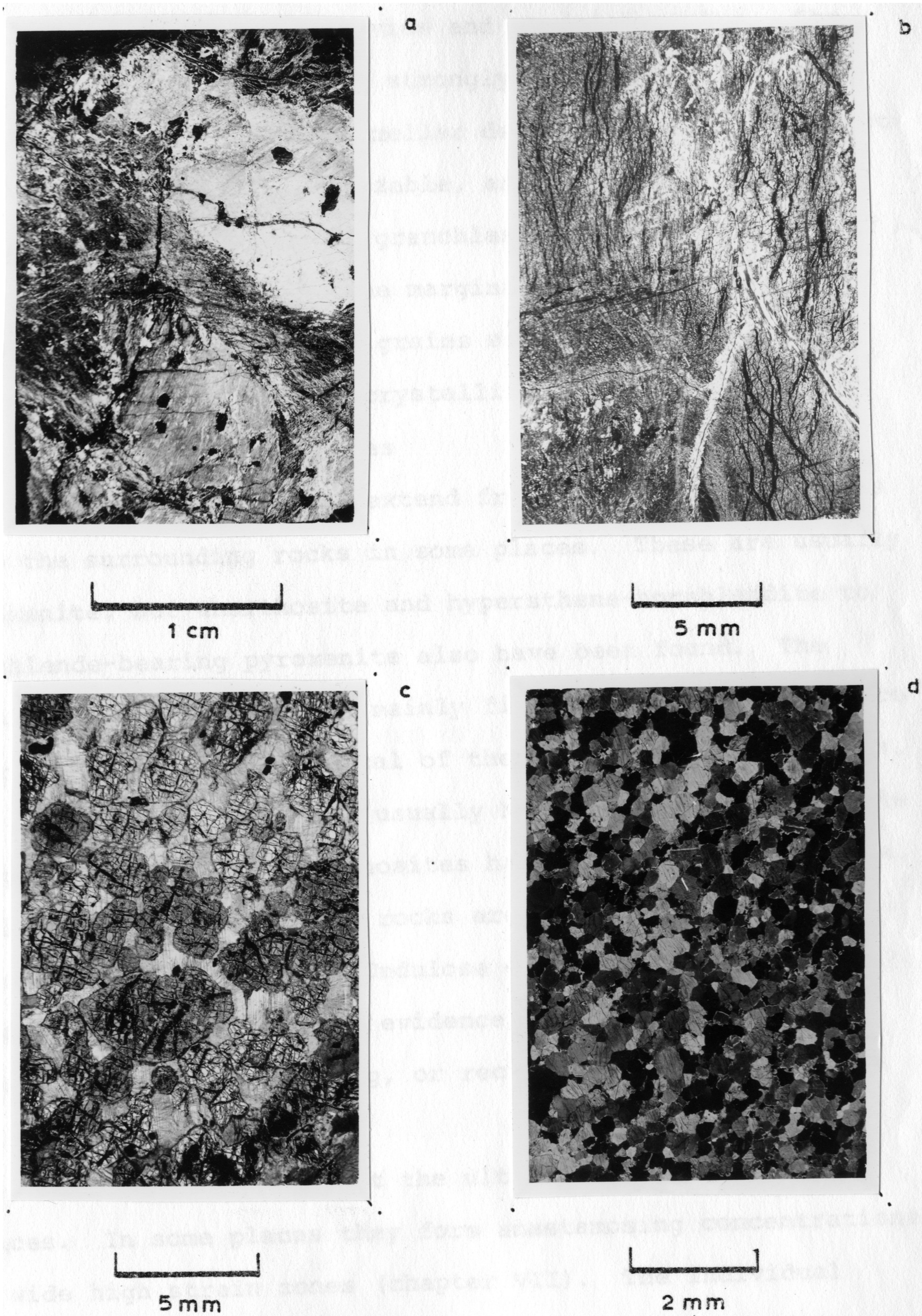


FIGURE 12

Figure 13 Photomicrographs of Bay of Islands Complex rocks. a. weakly deformed chromitite cumulate with serpentinized postcumulus material (Hines Ponds area) crossed-nicols. b. weakly deformed and veined plagioclase cumulate with postcumulus olivine (anorthositic troctolite) (Rope Cove Canyon area), crossed-nicols. c. weakly deformed clinopyroxene cumulate with post cumulus olivine (wehrlite); note incipient grain boundary recrystallization, crossed nicols. d. same as c except nicols at 60°. e. partially recrystallized, protogranular, clinopyroxenite cumulate (Hines Pond area), crossed-nicols.

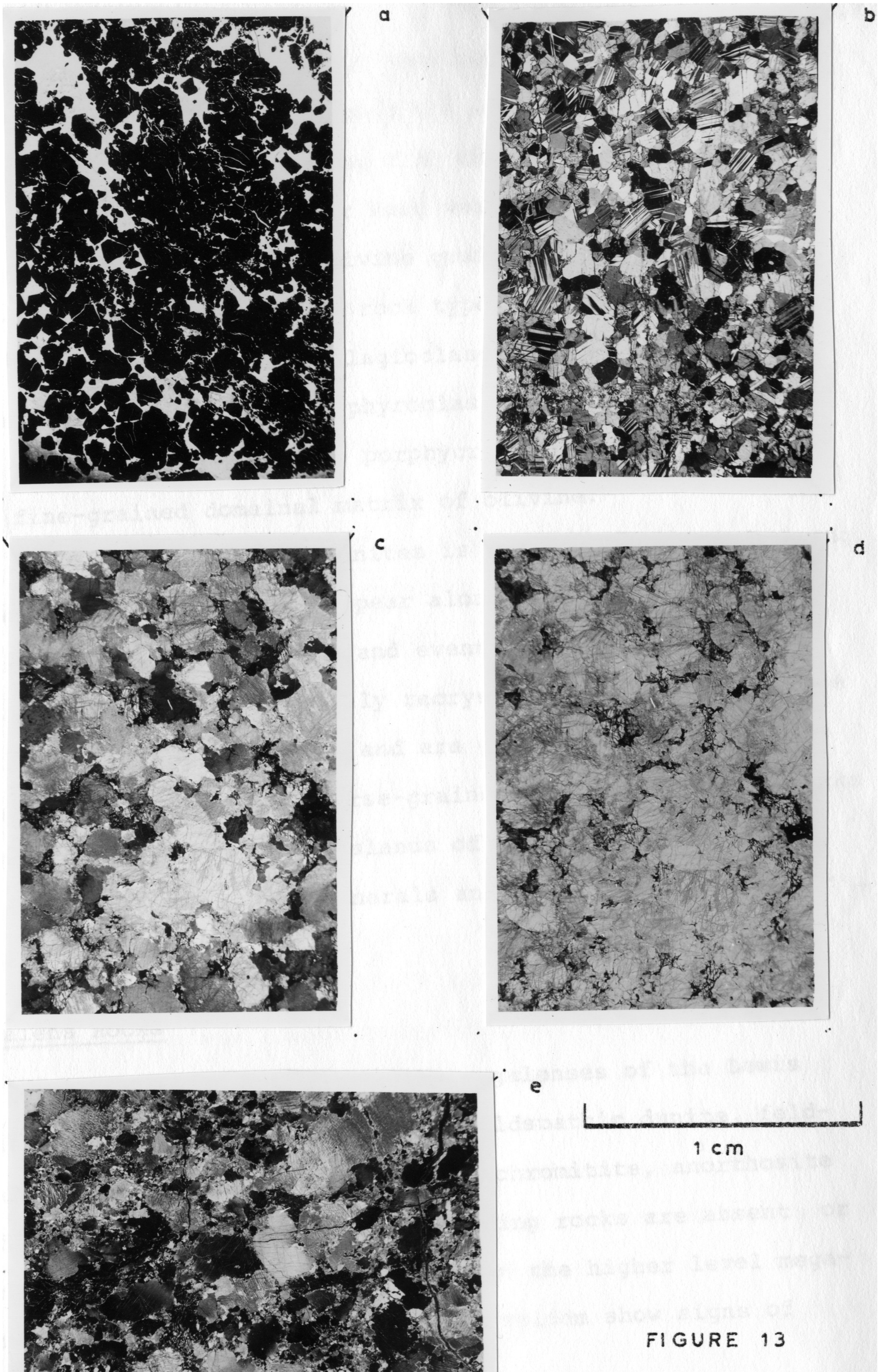


FIGURE 13

<u>Figure 14</u> Photomicrographs of high strain zone rocks

a. mylonitic feldspathic wehrlite with porphyroclasts of partially recrystallized, highly deformed clinopyroxene and plagioclase in a fine-grained, granoblastic olivine + clinopyroxene matrix.

b. similar to a but showing bent cleavage traces in clinopyroxene and lamellar deformation twins.

c. porphyroclastic feldspathic wehrlite with well developed domainal structure (see text), note well recrystallized domains of different grain size.

d. mylonitic amphibolite with augen of altered clinopyroxene; note development weak banding.

(a, b and c from high strain zone north of Hines Pond; d from west flank of Cloud Mountain).

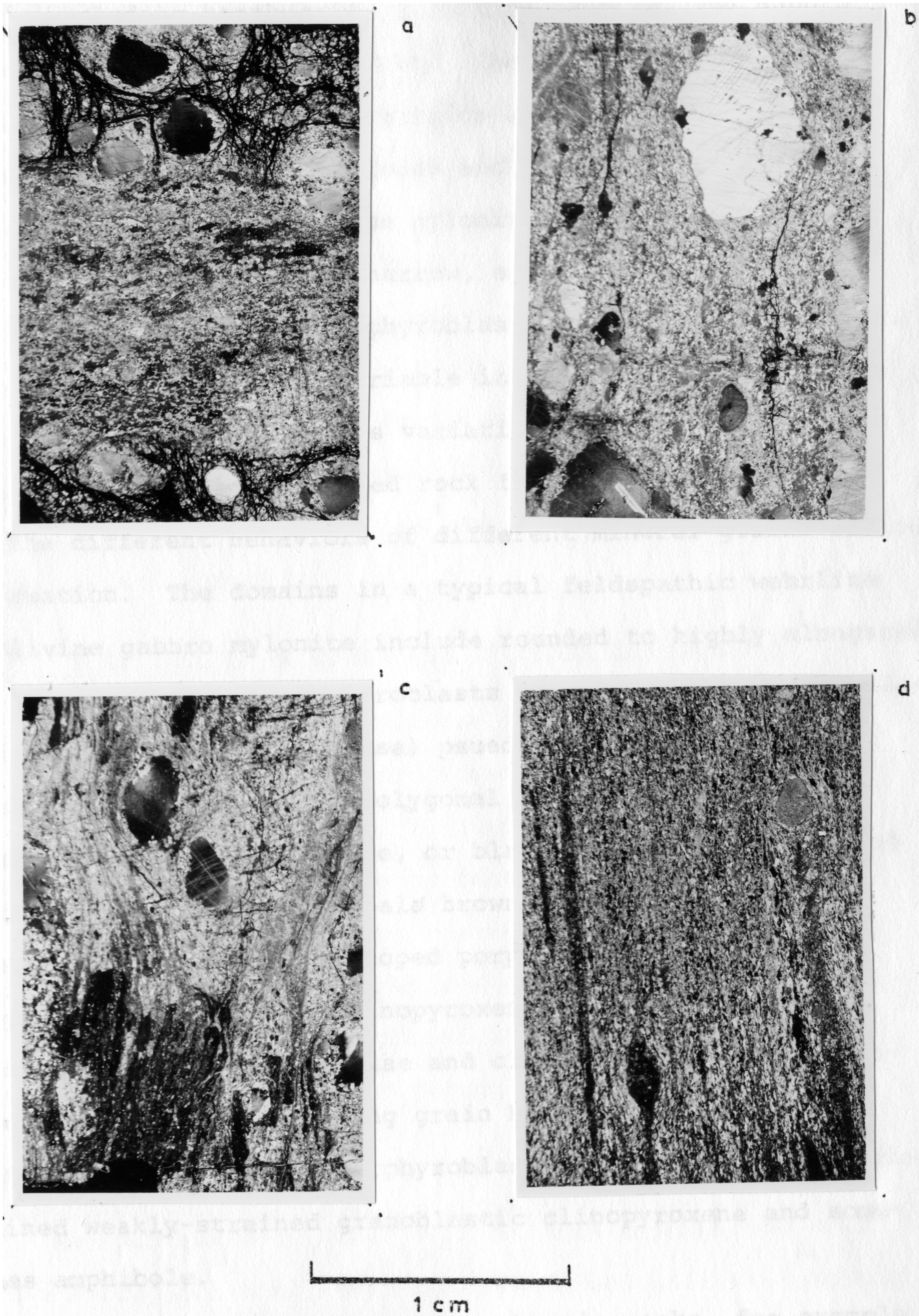
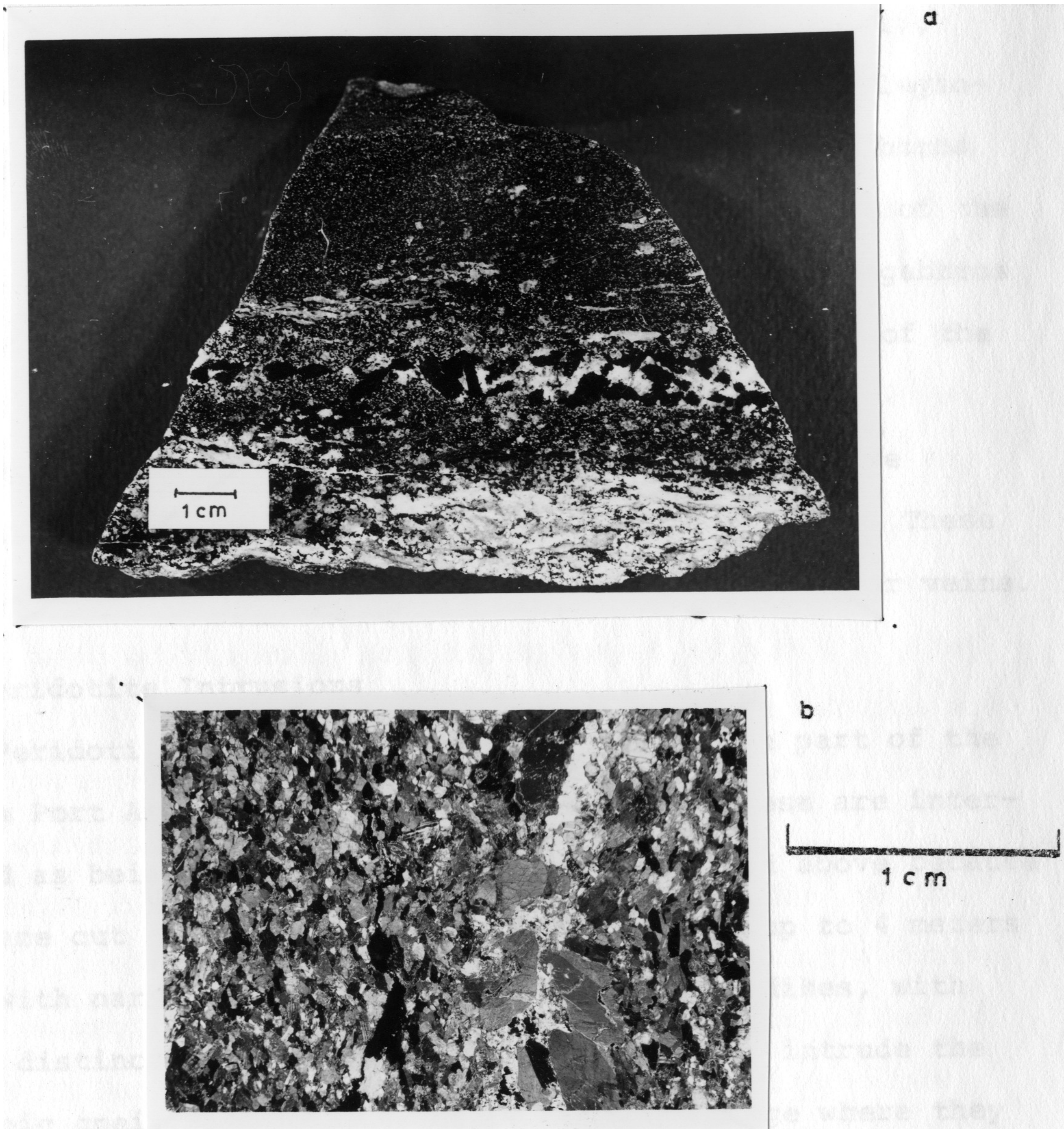


FIGURE 14



<u>Figure 17</u> Pegmatitic vein in quartz-diorite/diabase contact zone a. polished slab showing vein with coarse hornblende + plagioclase near parallel to the diabase vein (dark) / quartz-diorite (light) contact. b. photomicrograph of vein and surrounding rocks; note large, twinned hornblende crystals growing across fabric of finer-grained (meta)diabase.

a)

b)

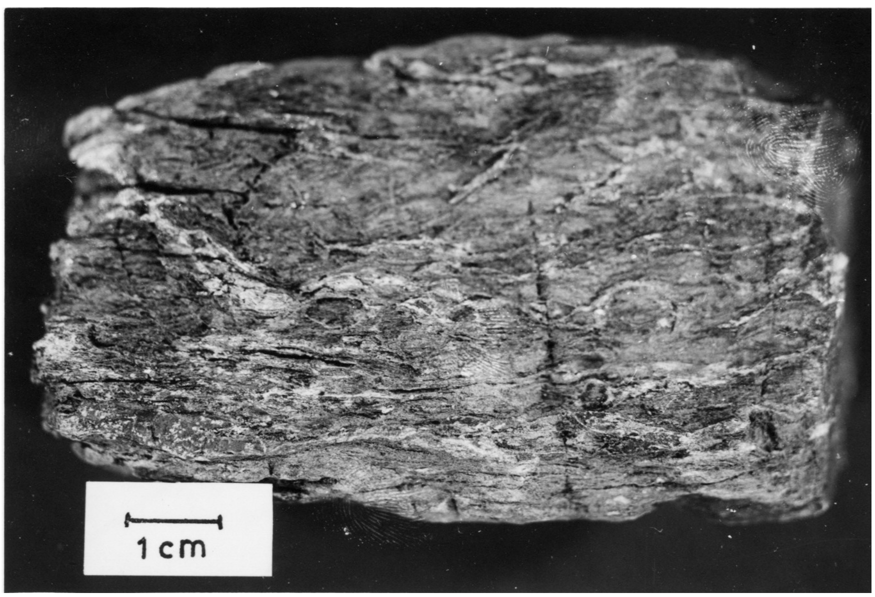


Figure 18 Serpentinite mélange a. phacoidal, shiny dark green serpentinite with blocks of less deformed ultramafic material and a highly altered, rounded block of metagabbro (light, lower left). b. hand specimen of mylonitic serpentinite, note anastamosing foliation similar to larger scale structure in a.

Figure 19 Complex relations in a metagabbro screen in the sheeted metadiabase dike region. A shear zone in metagabbro (left) with moderate lineation is cut by a later shear zone; both are cut by a pegmatite vein that is in turn cut by a diabase dike (dark grey). A shear zone with plagioclase porphyroclasts cuts all of the above and is cut by late joints and calcsilicate veins.

Figure 20 Exposure of sheeted metadiabase dikes in the precipitous west wall of the canyon of Molly Ann Brook; dikes dip steeply to the east-northeast (left).

FIGURE 19

FIGURE 20

Figure 21 Complexly interlayered quartz-diorite to trondhjemite (light) and metadiabase (dark) near Mount Barren (outcrop is underwater except block in lower left); probably the deformed contact between a quartz-diorite mass and surrounding metadiabase that included metadiabase xenoliths and veins and also trondhjemitic net vein breccias. (photo by S. O'Connell, 1976).

Figure 22 Mafic sheet in the MBA has coarse, nearly equant plagioclase megacrysts and is boudinaged. Mafic and leucocratic streaks in surrounding gabbroic gneiss define a strong lineation Lc_1 that is deformed near the boudin neck. (yellow green material is lichen)

FIGURE 21

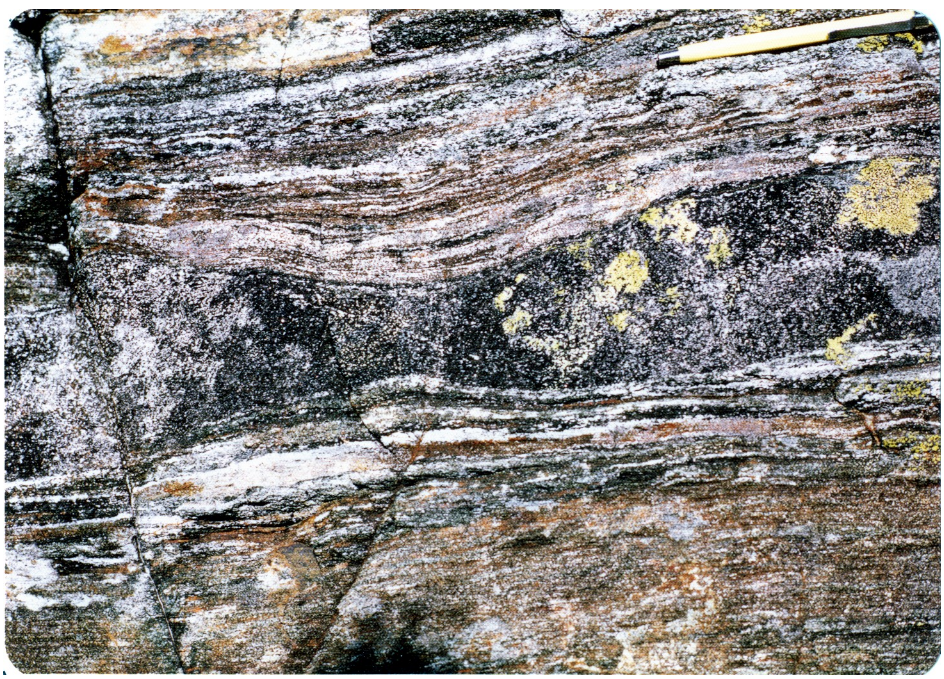


FIGURE 22

Figure 23 Secondary metamorphic layering in the MBA

a. secondary layering truncates deformed (cumulate?) layering in recrystallized olivine gabbro. b. photomicrograph of the secondary layering with granoblastic medium-grained plagioclase and fine-grained brown hornblende, clinopyroxene and hypersthene.

Figure 24 Isoclinal fold with limbs attenuated along mylonitic dislocation zones with secondary layering, MBA east of Lion of Babylon Pond.

a)

b)

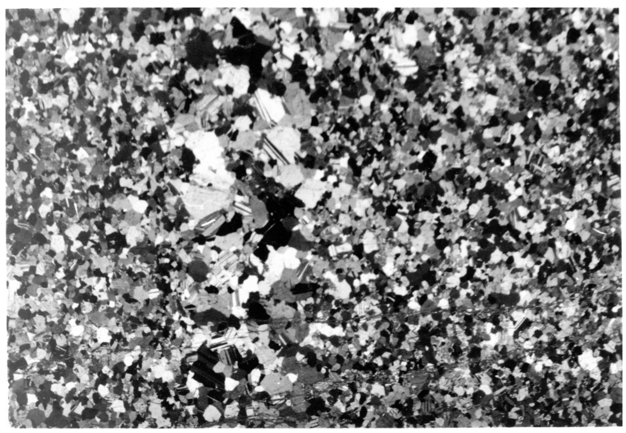
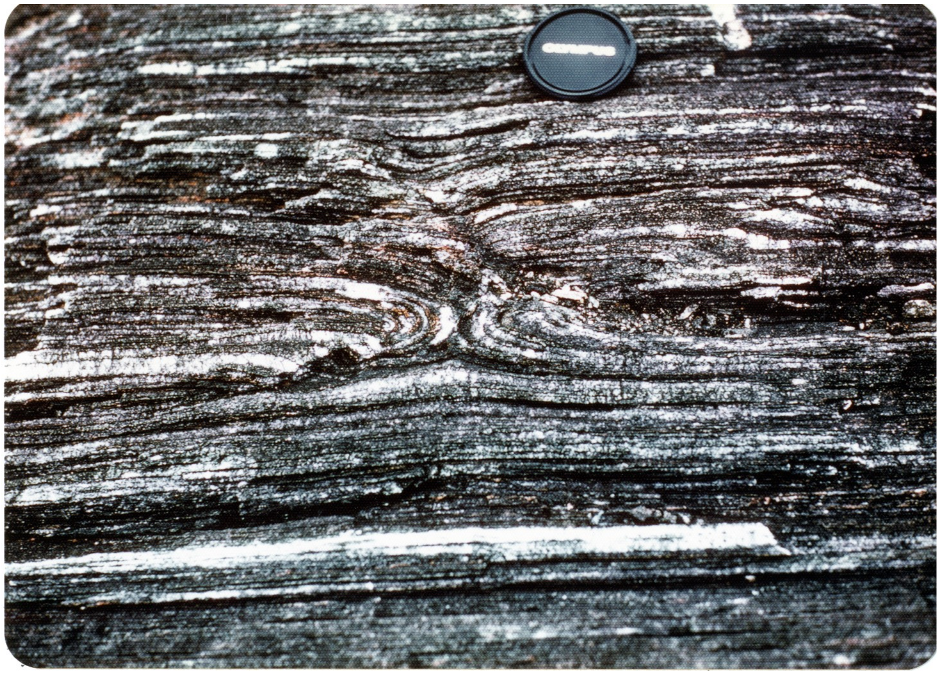


FIGURE 23

FIGURE 24

Figure 25 Apparent 'double-fold' structure in MBA gabbroic gneiss a. outcrop photo (by W.S.F. Kidd, 1976). b. schematic diagrams for a possible evolution of the structure in a : A-layered or lineated gneiss, B-internal boudinage, C-shear zone, with same sense of shear displacement as across boudin surfaces, cuts boudin neck.



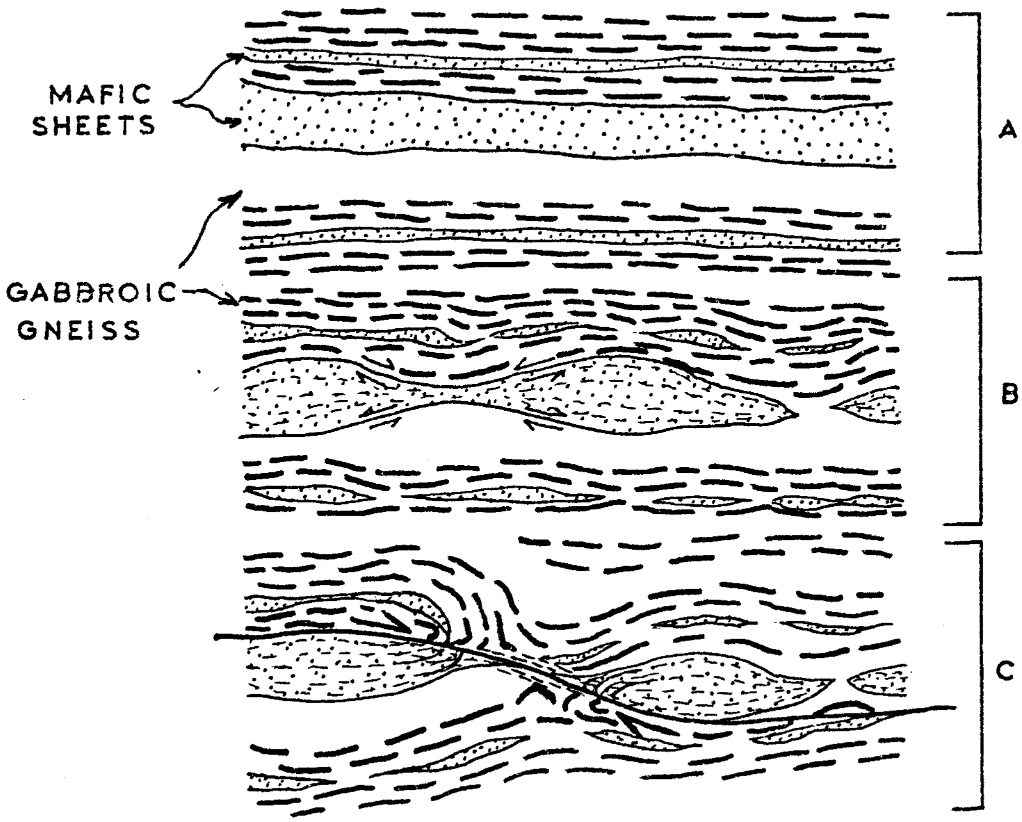


FIGURE 25

Figure 26   Sketch of pegmatite patch (coarse dashes) and associated hornblendite (fine dashes) that cut a shear zone cutting the mesoscopic lineation in gneiss (stippled-mafic domains, blank-leucocratic domains); from outcrop sketch and photograph in MBA near Lion of Babylon Pond.

Figure 27   Hornblendite veins cut folded lineation in gabbroic gneiss; lineation is defined by granoblastic aggregates of plagioclase, pyroxene, hornblende or a combination of either two or all three minerals.

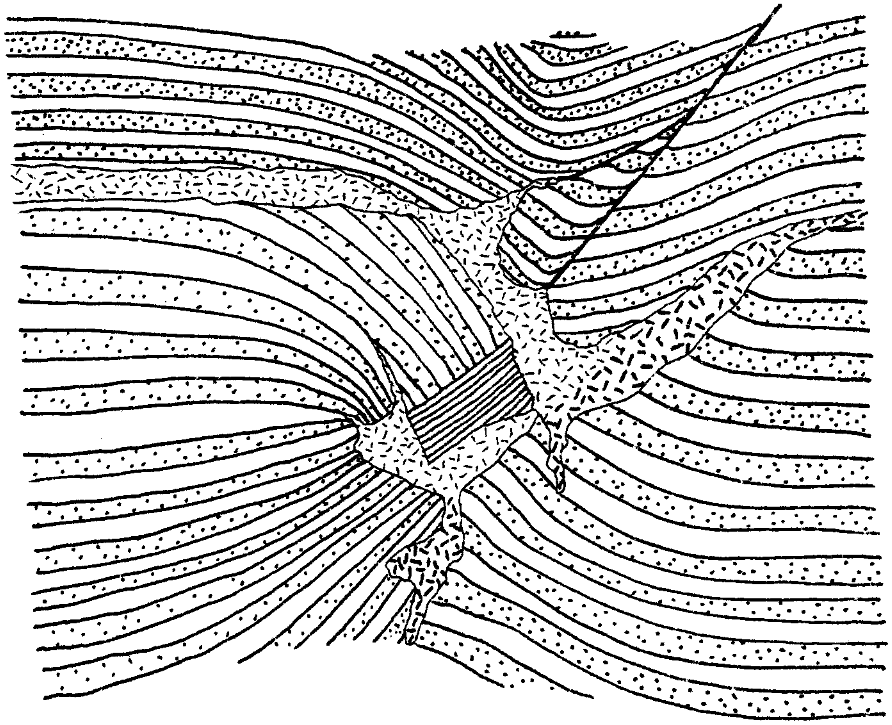


FIGURE 26

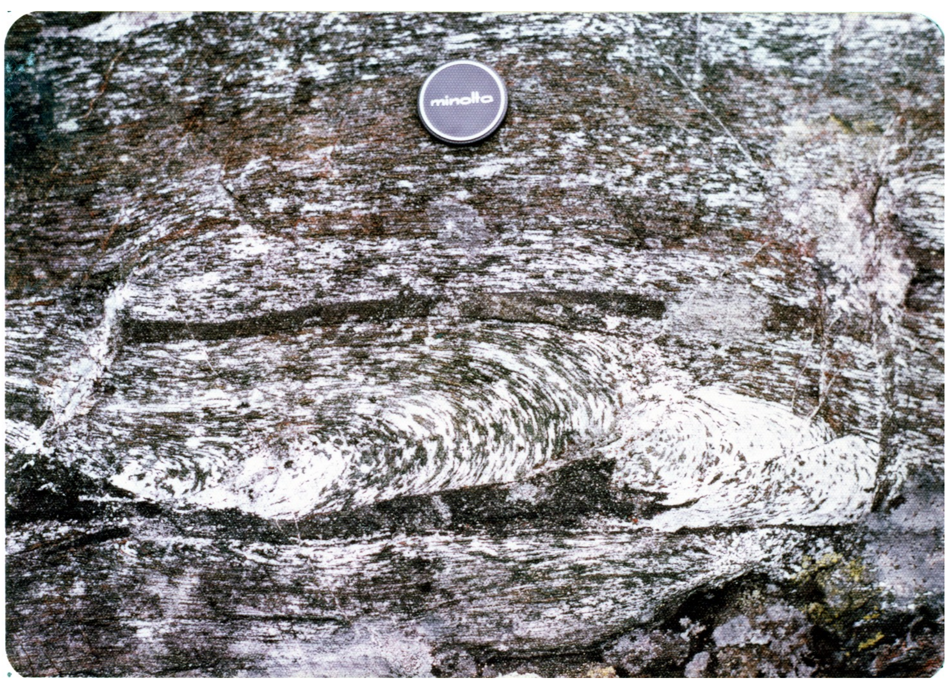


FIGURE 27

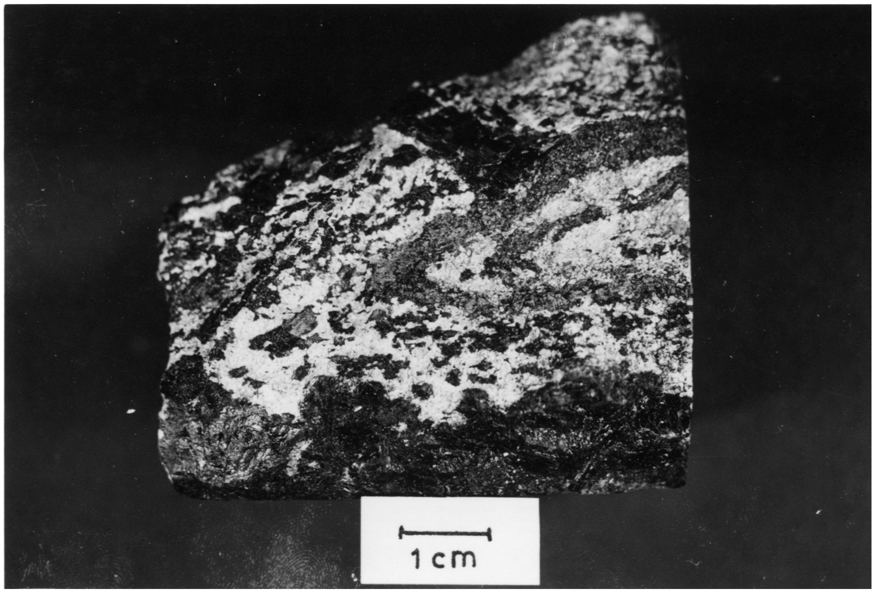


Figure 28   Hand specimen of gabbroic gneiss with folded layering cut by coarse hornblendite (black, bottom) and a large hornblende porphyroblast (top).

a)

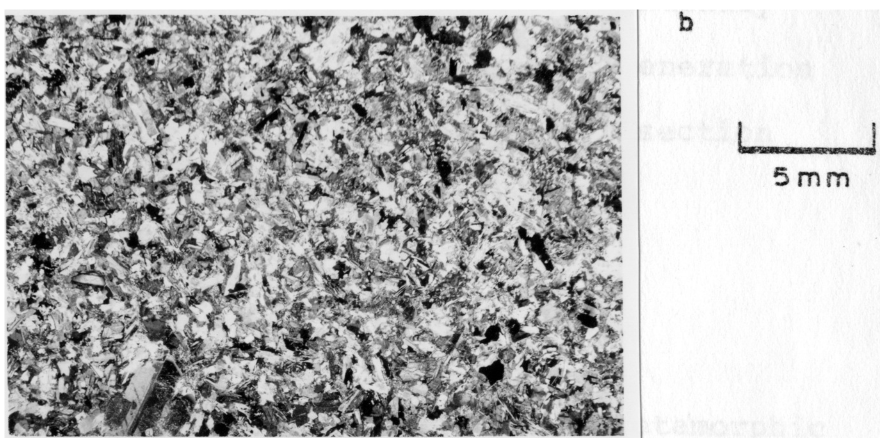


Figure 29 Fine-grained, brecciated hornblende-microgabbro dike cuts layering and strong lineation in gabbroic gneiss of the MBA in a. Dikes have chilled margins and interiors with subophitic texture and sparse plagioclase phenocrysts b.

Figure 31 Feldspathic lherzolite a. grades into fine-grained lherzolite at the margin of the peridotite pluton (MBA).

Figure 32 Spongy surface texture of the feldspathic lherzolite with plagioclase (white) oikocrysts enclosing small, less resistant olivine grains (gold); dark green material is clinopyroxene, orthopyroxene or amphibole (pargasite?) oikocrysts.

Figure 33 Contact between intrusive peridotite (olive brown) and altered, lineated gabbroic gneiss (light grey); note angular xenolith of gneiss in peridotite (center), small, fine-grained apophyses of peridotite intruding the gneiss (left), and streaky segregations of clinopyroxene parallel to the contact (right center).

a)

b)

Figure 34 Lherzolite dike in complexly layered olivine gabbro a. dike cuts layering in boulder west of Carol Mountain b. photomicrograph of fine-grained contact between serpentinized lherzolite (left) and coarse-grained olivine gabbro (right) with possible cumulate texture.

(specimen provided by Dr. A. R. Berger)

Figure 35 Clinopyroxenite masses and schlieren in lineated wehrlite to lherzolite at the contact of the peridotite with gabbroic gneiss (right).

Figure 36 Sketch of outcrop relations of isotropic wehrlite to lherzolite (stippled), isotropic, coarse-grained clinopyroxenite (coarse, random dashes), dunite (blank) and lineated (±foliated) wehrlite to lherzolite (fine dashes).

FIGURE 35

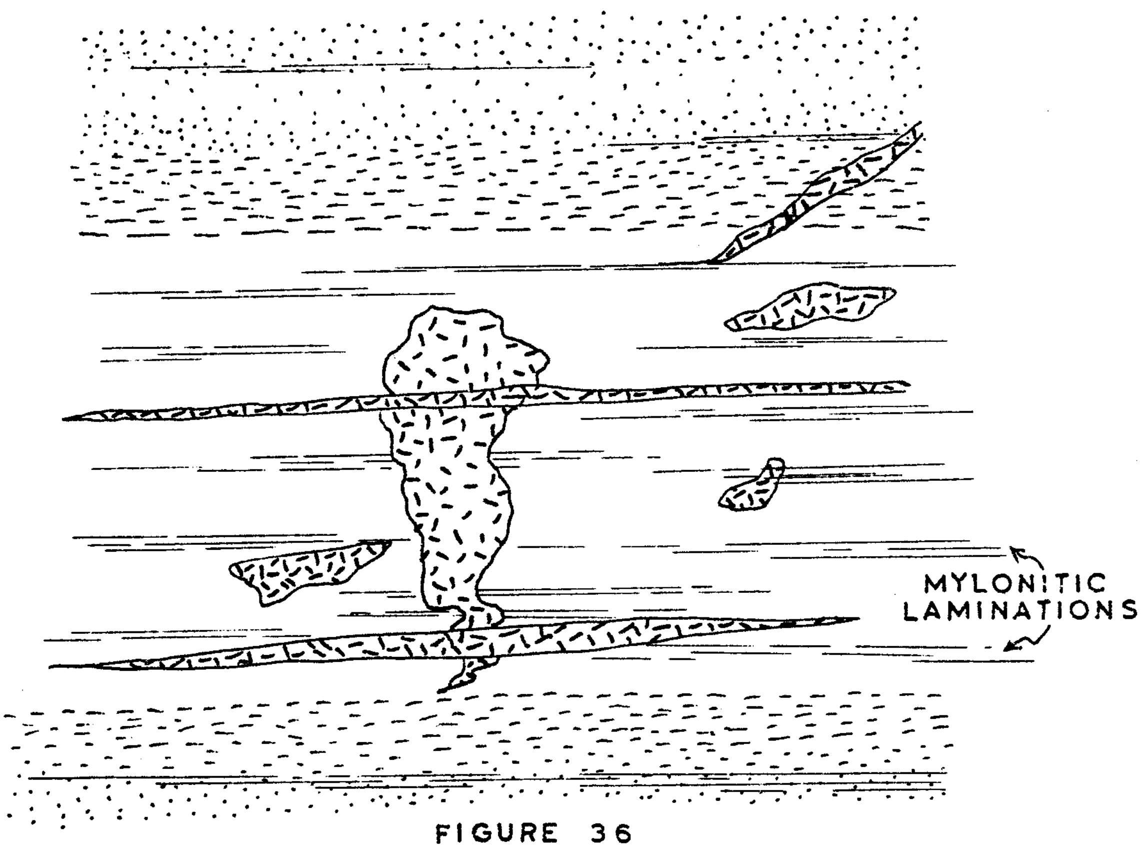


FIGURE 36

Figure 37 Layering in the interior of the peridotite pluton in feldspathic lherzolite, feldspathic dunite, and dunite; plagioclase crystals are more resistant than the other types present and are white on the weathered surface.

Figure 45 Layered tectonic megalens north of Hines Pond, with layered gabbro (grey), wehrlite (brown) and dunite (yellow gold); white patches are snow banks; top to bottom of photo is approximately 4 km. Megalens is offset by high strain zones (top center). (Photo taken from float plane at approximately 3000 feet elevation).

Figure 46 Isoclinally folded anorthosite (white) and dunite (gold) in mainly feldspathic wehrlite; fold limb is attenuated along a layer parallel dislocation zone; note traces of discontinuous plagioclase-rich layering and preferred orientation of grains in feldspathic wehrlite are parallel to the foliation in the hinge region of the fold. All lithologies in the outcrop have a strong stretching lineation oriented parallel to the fold axis.

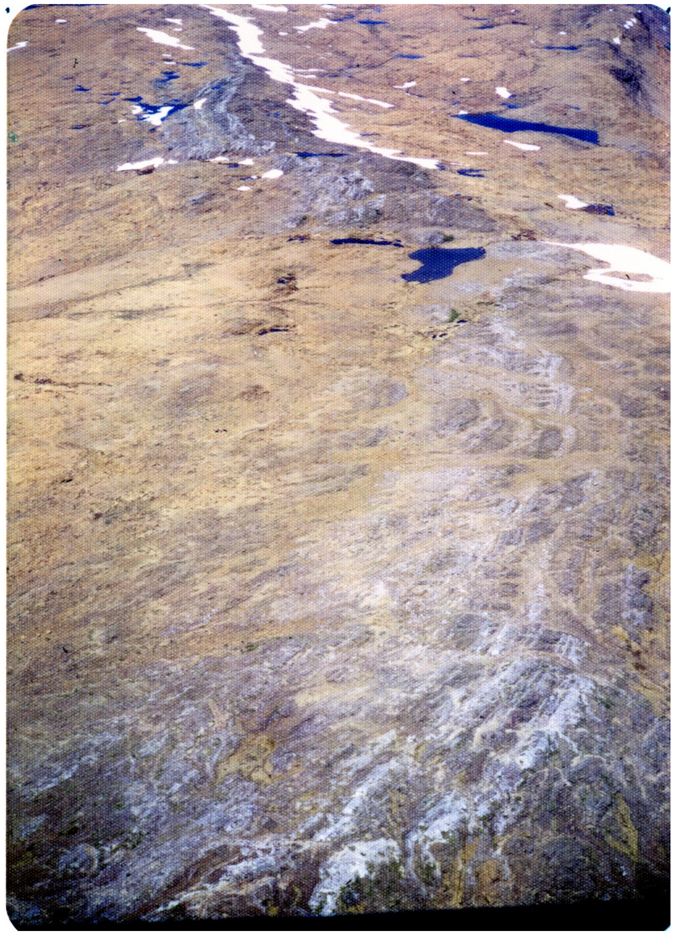


FIGURE 45

FIGURE 46

Figure 47 Deformed, layered cumulate clinopyroxenite and dunite; the dunite has well developed schistosity and the clinopyroxenite has tension joints that do not cut the dunite layers, probably a result of incipient brittle boudinage of the clinopyroxenite layers.

Figure 48 Streaky plagioclase-rich layering in coarse-grained feldspathic wehrlite to olivine gabbro; small, round masses and a dike of material similar in composition to that of the small scale layers cut those layers and large scale layering with dunite (gold) along a sharp offset in the large scale layering. The small scale layers may be, in part, cumulate layers, but some are also probably formed by segregation of plagioclase-rich liquid along layer parallel dislocation zones.

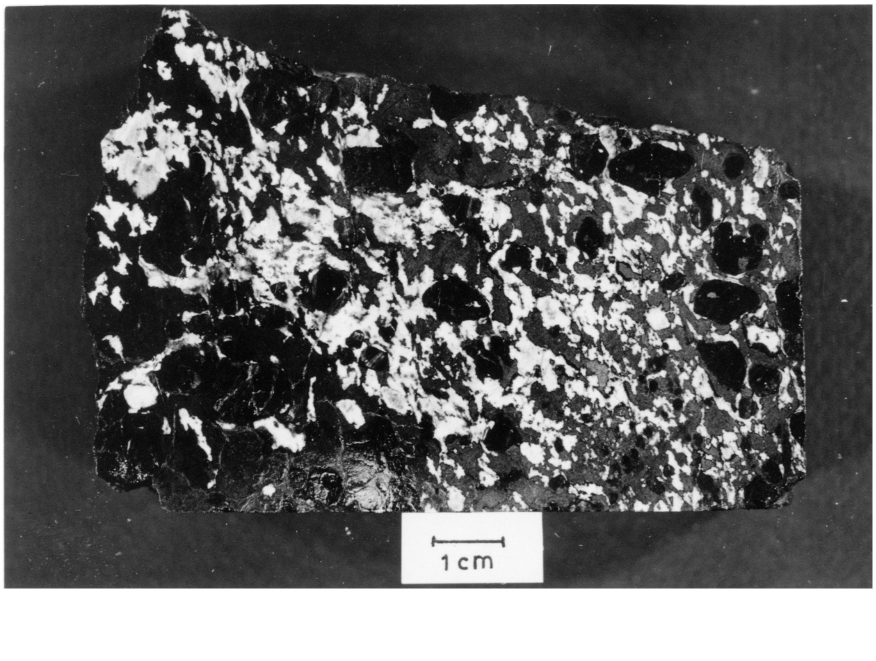
FIGURE 47

FIGURE 48

Figure 49 Deformed small scale (cumulate?) layering in dunite (gold) and clinopyroxenite (green); the layering is isoclinally folded and transposed such that it is still approximately parallel to the undisturbed large scale layering nearby (not shown).

Figure 50 Typical fabric of an olivine gabbro to feldspathic wehrlite tectonic from Cloud Mountain. Polished slabs show 3 mutually perpendicular faces a. normal to the lineation, b. parallel to the lineation normal to the layering plane (top), and parallel to the layering plane (bottom); note in a, clinopyroxene (black) is often euhedral while plagioclase (white) is subhedral to anhedral and olivine (grey) is very irregularly shaped; and in b, individual clinopyroxenes are stretched, boudinaged and ripped apart, plagioclase has streaky and augen shapes and olivine is very irregularly shaped though generally in very elongate domains; the plagioclase and (weaker) olivine appear to have been molded around the large clinopyroxene augen. Rocks with similar textures are typical of the tectonic megalenses.

a)



b)

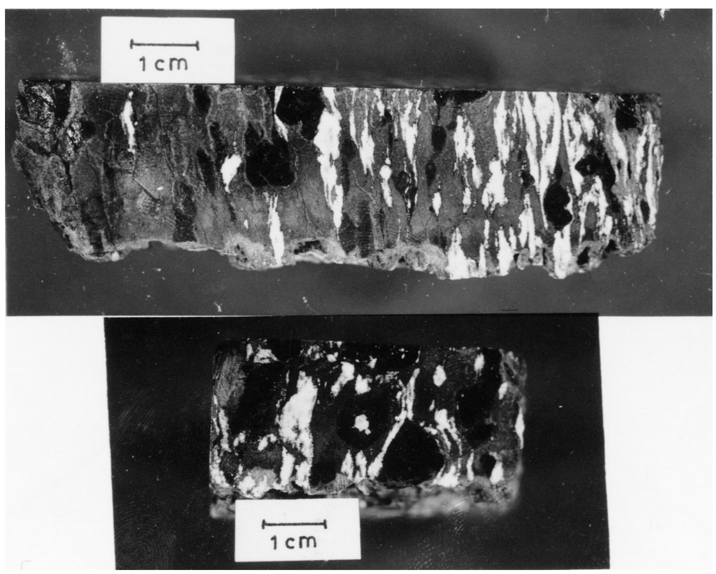


FIGURE 50

Figure 51 Crosscutting wehrlite dikes (brown) in dunite (gold). The smaller dike cuts cumulate chromite-rich layering in the dunite at a low angle (upper right) and is itself offset and cut by a later, large dike; note: sharp planar walls of the dikes and their coarse-grained texture; weak preferred dimensional orientation of clinopyroxene grains in the later dike. The clinopyroxenes in the dikes are affected by a weak stretching lineation (approximately normal to this surface).

Figure 52 Tightly folded cumulate layering in olivine gabbro, anorthosite and dunite. Rocks do not have a strong lineation but do have a strong preferred dimensional orientation of plagioclase streaks parallel to the fold axial surface and the dislocation zone along which the fold limb is attenuated. (from central megalens west of the Fox Island River).

FIGURE 51

FIGURE 52

Figure 53 Coarse-grained layered cumulate anorthositic troctolite to olivine gabbro with low angle cross-bedding; beds at base of outcrop are inclined and truncated by those at the top (horizontal trace of layering) (author for scale). A typical layered gabbro from the highest level megalenses.

Figure 54 a. Cumulate feldspathic dunite to troctolite with concordant tabular and angular blocks of coarse-grained anorthositic troctolite (white). Some plagioclase-rich domains here may be trough structures or dislocation zone segregations. Outcrop is 20 meters from the contact with the MBA.

b. Detail of outcrop in a. Plagioclase (white) in the block is blocky and coarse-grained but that in the surrounding cumulate troctolite is tabular and somewhat finer-grained and has a strong planar preferred dimensional orientation. Note how this foliation is slightly depressed beneath the block and how individual tablets of plagioclase are stacked against the edges and top of the block. This fallen block has probably been buried by deposition of plagioclase and olivine crystals (gold).

a)

b)

FIGURE 54

Figure 55 Anastamosing shear zones separate phacoidal blocks of coarse-grained strongly lineated feldspathic wehrlite; the lineation has a sigmoidal trace through many blocks; note incipient development of weak layering within the shear zones. A typical exposure of the high strain zone north of Hines Pond.

Figure 56 Very strong stretching lineation in wehrlite to feldspathic wehrlite. Pencils of clinopyroxene, knots of plagioclase, and coarse augen of both minerals weather in positive relief relative to the highly recrystallized olivine matrix. This lineation (Lb_2) is only found in the high strain zones.

FIGURE 55

FIGURE 56

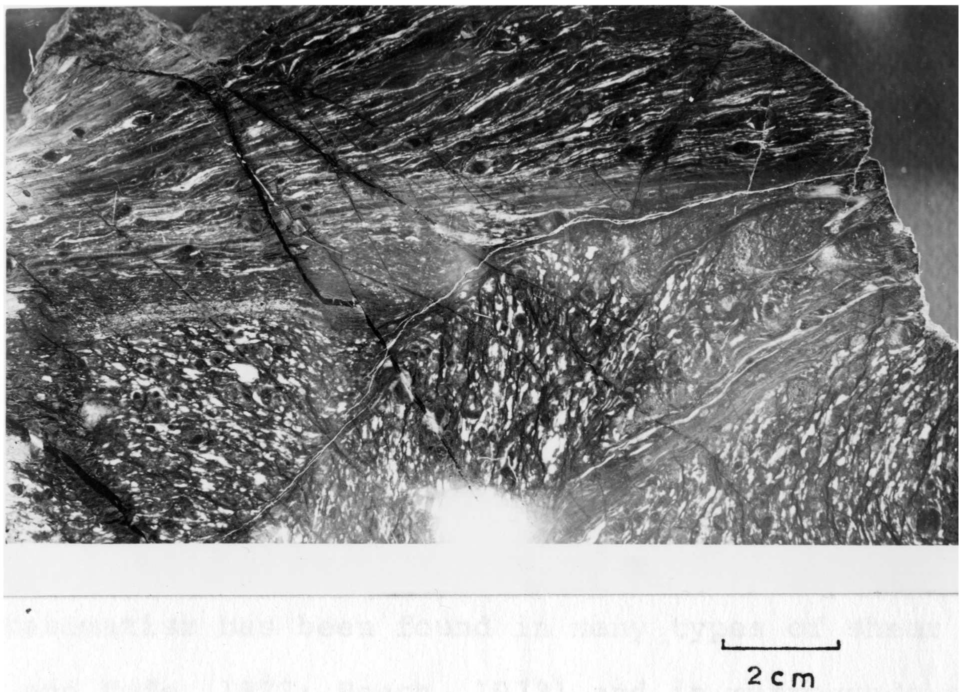


Figure 57 POLISHED SLAB FROM THE CLOUD MOUNTAIN HIGH STRAIN ZONE

Anastamosing shear zones, with very mylonitic porphyroclastic central regions, separate phacoids of less deformed lineated gabbroic to feldspathic ultramafic material. Similar rocks comprise the high strain zone areas of the BOIC. Note : the apparent sense of displacement across individual shear zones is not consistent.

<u>Figure 63</u> Discontinuous cumulate chromitite layering (black) in layered wehrlite (gold) and gabbro (grey); medium-grained wehrlite dike cuts the layering and has sharp, planar walls.

Figure 64 Chromite concentration (black) in the hinge of an isoclinally folded dunite layer (gold) within coarse wehrlite (grey) note transposed nature of chromitite layers.

Figure 65 Isoclinally folded cumulate layering in dunite (gold) and chromitite or chrome-rich gabbro (black), southeast of Hines Pond; note lack of axial surface foliation.

FIGURE 64

FIGURE 65

Figure 66 Irregular masses, veins and schlieren of chromitite (black) in dunite (gold) near the margin of the peridotite pluton; note podiform chromitite distributed around the larger masses of chromitite.