SECTION 5 : AGGREGATE PROPERTIES OF FINE- AND FINE-TO MEDIUM-GRAINED GRANITES FROM ANDERSON ROAD

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FOREWORD

In order to help provide the Materials Division and the Hong Kong Geological Survey with much needed data on the characterisation and possible usage of each of the Territory's major rock types the Office initiated the Fresh Rock Testing Programme in 1985.

This report forms part of the Fresh Rock Testing Programme and is one of a series of reports which presents the results of selected aggregate and index laboratory testing carried out on fresh block samples of discrete rock types.

The rock types described in this report are fine- and fine- to medium-grained granites from the Pioneer Quarry, Anderson Road.

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1. INTRODUCTION

This report presents and discusses the results of selected physical index and aggregate testing on laboratory crushed fine- and fine- to medium-grained granite samples from the Pioneer Quarry, Anderson Road. The results are compared with the routine test values available on quarry run material from the Pioneer Quarry and the suitability of both rock types as aggregate is assessed in comparison with the typical acceptance values for various uses.

2. SITE DESCRIPTION AND SAMPLING

The sampling site is at the northwestern part of the Pioneer Quarry along Anderson Road, Kowloon (Figure 1, Plate 1). Quarrying operations at both the Pioneer Quarry and the adjacent Ka Wah Quarry started as a number of permit quarries pre-1960's on the southwestern flank of an elongate hill (Tai Sheung Tok) rising up to 420 mPD (Figure 1). Large scale quarry operation started at the western part of the site in 1962 by Ka Wah and the contract for quarrying the eastern part of the site was let to Pioneer in 1974 by the Government. The current combined annual production is 3.0 million tonnes.

Fine- and fine- to medium-grained granite block samples were collected from the newly excavated rock stockpile on the 245 mPD platform (Plates 2 and 3). The exact location of the samples on the quarry face is not known, but the majority of the rock in the stockpile is considered to come from the faces above the platform (Plate 2).

The samples collected appeared to be typical and representative of both granite types occurring throughout the quarry. The currently worked faces of the Pioneer Quarry are dominantly in fine-grained granite (Figure 2) with fine- to medium-grained granite outcropping in the lower faces and the quarry platform.

3. GEOLOGY

3.1 Site Geology

A detailed account of the geology and engineering geology of both quarry sites is given in the Advisory Report ADR 12/86 "Engineering Geology Studies for the Extension of Anderson Road Quarries" (Choy & Irfan, 1986). The site is underlain by granite with volcanic rocks occupying the summit region of Tai Sheung Tok. The granite-volcanic contact crosses the uppermost quarry face in the Ka Wah Quarry (Figure 2).

The granite is grey to pinkish grey, equigranular, and generally of grain size of 1 to 4 mm along the lower reaches of the quarries. It is shown on the new geological map of Hong Kong and Kowloon (GCO, 1986) as fine- to medium-grained granite (gfm). This grades into a finer grained (less than 2 mm in grain size), inequigranular granite with scattered porphyritic feldspar crystals (fine-grained granite, gf) towards the contact with the pyroclastics. The granite generally contains small amounts of muscovite and less than 5% biotite.

Two sets of faults cross the quarry sites in NNW-SSE and NE-SW directions. Kaolin veins and pyrite mineralization is present along the fault zones which indicates hydrothermal alteration of the granite along these lines of weakness prior to weathering (Choy, Earl, Irfan & Burnett, 1987). The joint spacing is variable over the site in the Ka Wah Quarry where the NNW-SSE trending major fault zone passes very close to the current working quarry faces and the spacing is generally 0.5 to 1.5 m. In the Pioneer Quarry, the major faulted zone is well outside the current working limits or to the south and the discontinuity spacing is much wider except along the minor fault/shear zones where the spacing can be less than 0.3 m (Figure 2).

At the northwestern corner of the Pioneer Quarry, from where the samples were selected, the rock is generally slightly weathered. Pyrite mineralization was observed along some faults and joints with pyrite crystals also occurring in the rock some distance from the faults.

Strange and Shaw (1986) described the geology of both granite types occurring in the Territory.

3.2 Description of Test Sample

3.2.1 Fine-Grained Granite

(1) Engineering geological description. The rock is a very strong, light grey, crystalline, fresh to slightly decomposed, fine-grained (less than 2 mm) GRANITE with inequigranular and slightly megacrystic texture.

(2) Detailed description. The joint surfaces are stained light yellowish brown with some migration of discoloration, up to 10 mm, into the rock from the joint surface. Yellowish brown staining is also present around pyrite crystals scattered throughout the rock indicating slight decomposition of pyrite.

The major constituents of the granite are quartz, plagioclase and alkali feldspars. Small amounts of biotite and muscovite and pyrite are also present. Feldspars are milky white except near joint surfaces where they may be light pink in colour. Quartz forms about 32% of the rock and, biotite and muscovite less than 3%. The results of modal analysis carried out on three thin sections are given in Table 1. The rock is inequigranular and slightly megacrystic. The finer groundmass has as grain size of 0.1 to 1.0 mm with quartz and feldspar megacrysts up to 3 mm. Occasional feldspar megacrysts are up to 8 mm in grain size.

In thin section (Plates 4 and 5) some plagioclase and alkali feldspars show slight alteration in the form of either partial replacement by or growth of individual muscovite flakes (muscovite also occurs as a primary constituent). In addition, most plagioclases show slight alteration to minute sericite and clay minerals. Calcite was seen to be forming as decomposition product in one or two plagioclase grains. The total amount of feldspar alteration is about 3.7% of the rock (Table 1).

The grain boundaries are tight and interlocking. Occasional quartz-feldspar boundaries show iron-oxide staining. Microcracks are few (less than 1 per 10 mm) single, tight (less than 0.01 m in width) and generally intragranular in quartz and some feldspars. Very few transgranular microcracks of longer length are present.

3.2.2 Fine- to Medium-Grained Granite

(a) Engineering geological description. The rock is very strong, light grey, crystalline, fresh to slightly decomposed, fine- to medium-grained (1 to 4 mm) GRANITE with equigranular texture.

(b) Detailed description. The joint surfaces are stained light yellowish brown with some migration (a few mm) of discoloration into the rock from the joint surface. Slight decomposition of feldspars is evident near the joint surfaces. The feldspars are pink adjacent to one joint surface in one of the block samples indicating slight hydrothermal alteration.

The major rock constituents are quartz, plagioclase, alkali feldspars and biotite. Quartz forms about 38% and biotite less than 5% of the rock. The results of modal analyses carried out on three thin sections of granite are given in Table 2.

In this section (Plates 6 and 7) a few plagioclases and potash feldspars show slight alteration in the form of either partial replacement by or growth of individual muscovite flakes, but the replacement is much less intense than that of fine-grained granite (see Tables 1 and 2). In addition, most plagioclases show growth of minute flakes of sericite and clay minerals which may have formed as a result of weathering (Plate 7). The total feldspar alteration is about 6% of total feldspar content or 3.6% of the rock.

Although most grain boundaries are tight, some quartz-feldspar boundaries are stained indicating movement of iron-oxide from biotite alteration along the slightly open grain boundaries. Transgranular as well as intragranular microcracks exist with microcrack intensity being 2 to 3 per 10 mm. Microcracks are simple, tight and generally less than 0.02 mm in width; most are stained. Two thin micro-quartz veins were observed in one of the thin sections.

4. AGGREGATE TESTING AND CHARACTERIZATION

4.1 Sample Preparation and Testing Methods

75 mm diameter cores were drilled from the block samples using a coring machine in the Public Works Central Laboratory. Selected physical and rock index tests were performed on the cores. The remainder of the samples were broken into smaller pieces using a sledge hammer and a laboratory rock breaker. Point load testing was carried out on irregular lumps of rock using ISRM recommended method (ISRM, 1985). Standard (10 to 14 mm) and nominal 20 mm size aggregates (Plates 8 and 9) were prepared from the smaller pieces of rock using a laboratory jaw crusher.

The rock index tests undertaken included the determination of bulk density, porosity, water absorption, and sonic velocity using the PUNDIT equipment (ISRM, 1978). The aggregate tests included aggregate crushing value (ACV) aggregate impact value (AIV), water absorption, flakiness (I_F) and elongation indices (I_E) (BSI, 1975) and Los Angeles abrasion value (LAAV) (ASTM, 1981).

4.2 Classification and Characterization of Aggregate

The CADAM scheme recommended by the Geological Society Working Party on Aggregates (Collis & Fox, 1985) is used to describe and classify the aggregates (Tables 3 and 4). A more detailed petrographic evaluation of the aggregates is given in Tables 5 and 6.

4.3 Test Results

The results of the rock index tests on cores and irregular lumps are given in Table 7. The aggregate test results are tabulated in Table 8.

5. DISCUSSION ON TEST RESULTS

5.1 Rock Index and Aggregate Properties

The fresh to slightly decomposed fine-grained and fine- to medium-grained granites tested from Anderson Road are both very strong rocks with point load strengths in excess of 7.5 MPa and 7.1 MPa respectively corresponding to uniaxial strengths of 187.5 MPa and 177.5 MPa using the normal conversion factor of 25. They both have very low porosity and water absorption properties, less than 1.0% and 0.4% respectively (Table 7) and their densities are very similar. The slight difference in their strength properties is also reflected in the seismic velocities where a lower value of 3730 m/s was obtained on fine- to medium-grained granite against 4518 m/s for fine-grained granite.

Strength and sonic velocity values of granites are both influenced to a great extent by the degree of microfracturing and decomposition of the rock (Irfan & Dearman, 1978). The fine- to medium-grained granite in this study has more microcracks (2 to 3 per 10 mm) compared to the fine-grained granite (about 1 per 10 mm) and consequently lower strength value; the degree of decomposition measured by amount of feldspar alteration being almost the same for both granite types.

In terms of selected aggregate properties the fine-grained granite has significantly lower and hence more desirable properties in comparison with those of the fine- to medium-grained granite (Table 8). The aggregate properties of the latter rock are very similar to those of fine- to medium-grained granite from Mau Yau Tong (Irfan, 1987a) in terms of ACV, AIV, LAAV, I_F and water absorption value. The fine-grained granite from the Pioneer Quarry has the lowest and hence most favourable aggregate strength and abrasion properties amongst the granitic rocks tested in this study programme so far except for those of monzonite from Turret Hill where the rock tested was in fresh state (Table 9).

A comparison of the laboratory crushed aggregate test results with the mean values of quarterly results available from PWC Laboratory on quarry run material from Anderson Road quarries (Table 10) show that the fine- to medium-grained granite has very similar properties in terms of ACV, AIV, I_F and water absorption whereas those of the fine-grained granite are superior.

5.2 Suitability of Rock as an Aggregate

A comparison of the limited laboratory test results with typical, mainly UK, aggregate acceptance values (Table 7) indicates that the properties of aggregate produced from the fine-grained granite are well within the acceptable limits for both general use in concrete and as roadstone. The low aggregate test values obtained in terms of AIV and LAAV suggest that this rock type may be suitable for some special purposes such as wearing surface and high strength concrete whereas the fine- to medium-grained granite has marginal values in terms of ACV, AIV and LAAV making it less desirable for special purposes when compared to fine-grained granite or basaltic rocks. A LAAV test value of 44 obtained for this granite type is just outside the maximum value of 40 specified by the Australian Standard AS 2258 for concrete exposed to average conditions.

Polished stone values, 10% fines values and chemical reactivity of the aggregates were not determined in this study.

The aggregates from Anderson Road quarries have been successfully used for many years for general concrete purposes in Hong Kong, although for some special uses volcanic rocks were considered (e.g. Kai Tak airport runway). The aggregate test values reported in Table 10 are those of the mean values of quarterly tests carried out in the PWC Laboratory for the years from 1975 to 1985. In the original data no distinction was made between the various types of granites present in the quarry. Figure 2 suggests that the bulk of the rock excavated for aggregate was from the fine-grained granite in the Pioneer Quarry. The majority of the production faces in the quarry are in the slightly weathered granite zone with some moderately weathered granite along fault zones and higher levels in the quarry (Choy & Irfan, 1986). The quarried material is therefore likely to contain fresh and slightly decomposed granite as well as some moderately decomposed granite (i.e. completely discoloured), which can be suitable if of high strength and low porosity. The rocks tested in this study were fresh to slightly decomposed granite and came from the slightly weathered zone in the quarry.

The samples collected from the fine-grained granite had pyrite crystals disseminated throughout the rock. Some forms of pyrites are able to oxidise, with resultant expansion, when situated at or near concrete surfaces. This activity thus leads to the development or surface defects with considerable staining of the surface by iron oxide. The surface deterioration is usually of no structural significance, but the unsightly appearance may be undesirable (Collis & Fox, 1985).

6. CONCLUSIONS

The laboratory test results on laboratory crushed aggregates from fresh to slightly decomposed fine-grained granite from the Pioneer Quarry are well within the commonly accepted limiting values for general use in concrete and as roadstone, while those of fine- to medium-grained granite from the same locality are marginal in terms of ACV and AIV. The lower values make the fine-grained granite suitable for special uses such as wearing courses and heavy duty concrete floors. While the fine- to medium-grained granite is still suitable for general concrete uses, high aggregate strength test results near to the limiting values and a very high LAAV value of 44 make the aggregates produced from this rock type rather undesirable for some specific uses.

Although the bulk excavation for aggregate came from the fine-grained granite in the quarry, the average values obtained on quarry run material are higher and near to the limiting acceptance values than those determined on the samples chosen from the same granite type in this study. This is attributed to the fresher state of the rock used for laboratory testing in this study than those normally used for producing aggregate in the quarry. There is also variation in grain size even within the rock unit mapped as fine-grained granite in the vicinity of the quarry with grain size becoming finer towards the contact with the volcanic rocks.

Field observations indicate that the quality of granite near the fault zones is affected by more intense differential weathering and earlier hydrothermal alteration. Pyrite is present in the rock adjacent to such zones of alteration. Pyrite may cause staining if oxidized at or near concrete free surfaces; the surface deterioration is usually of no structural significance.

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Table 1 - Modal Analysis of Fine-Grained Granite from the Pioneer Quarry

Mineral	Feldspars %	Quartz %	Biotite %	Muscovite %	Others %
Thin Section 1	60.3 (2.1)	36.7	0.8	2.1	0.1
Thin Section 2	63.5 (4.1)	32.1	0.6	3.5	0.2
Thin Section 3	69.6 (4.9)	28.0	1.3	0.7	0.3
Average	64.6 (3.7)	32.3	0.9	2.1	0.2

Note : The number in brackets is the percentage of altered feldspars (kaolinite, sericite, etc.) per thin section.

Table 2 - Modal Analysis of Fine- to Medium-Grained Granite from the Pioneer Quarry

Mineral	Feldspars %	Quartz %	Biotite %	Muscovite %	Others %
Thin Section 1	56.8 (3.7)	41.4	1.4	0.3	0.0
Thin Section 2	63.4 (2.5)	34.2	1.5	0.3	0.3
Thin Section 3	59.5 (4.7)	37.7	2.2	0.1	0.3
Average	59.9 (3.6)	37.8	1.7	0.2	0.2

Note : The number in brackets is the percentage of altered feldspars (kaolinite, sericite, etc.) per thin section.

Table 3 - Description and Classification of Aggregate from the Pioneer Quarry by the CADAM System (Fine-Grained Granite)

AGGREGATE FORM	Crushed Rock		~~Gravel~~	~~Natural~~ / ~~Crushed~~ / ~~Mixed~~		~~Sand~~	~~Natural~~ / ~~Crushed~~ / ~~Mixed~~		~~Land-won~~ / ~~Marine Dredged~~	
CLASS (or MISCELLANEOUS)	~~Carbonate Class~~		~~Quartz Class~~	Silicate Class: Igneous		~~Sedimentary~~	~~Metamorphic~~		~~Miscellaneous Material~~ (correct name to be given below)	
Petrological name (if known)	GRANITE									
GEOLOGICAL AGE/ COLOUR/ GRAIN SIZE FISSILITY	Mesozoic/Light grey/Fresh to slightly weathered/Medium grained/No fissility									
Comment (if any)	Contains pyrite crystals									

Compiled by : T.Y. Irfan
SGE/EG, GCO

Date : 5.11.1987

CADAM - CLASSIFICATION and DESCRIPTION of AGGREGATE MATERIAL

LOCATION AND SAMPLE DETAILS	Quarry/Pit address : Pioneer Quarry Anderson Road, Kowloon Operator : Pioneer Sample : Type Blocks Size 50 kg Preparation Lab. crushed Supplied by EG Section	Grid Ref. 842310E 821320N Date of sampling	Date Rec'd Sampling Cert. No.

Table 4 - Description and Classification of Aggregate from the Pioneer Quarry by the CADAM System (Fine- to Medium-Grained Granite)

AGGREGATE FORM	Crushed Rock		~~Gravel~~	~~Natural~~ ~~Crushed~~ ~~Mixed~~		~~Sand~~	~~Natural~~ ~~Crushed~~ ~~Mixed~~		~~Land won~~ ~~Marine Dredged~~
CLASS (or MISCELLANEOUS)	~~Carbonate Class~~		~~Quartz Class~~		Silicate Class: Igneous	~~Sedimentary~~	~~Metamorphic~~		~~Miscellaneous Material (correct name to be given below)~~
Petrological name (if known)	GRANITE								
GEOLOGICAL AGE/ COLOUR/ GRAIN SIZE FISSILITY	Mesozoic/Light grey/Fresh to slightly weathered/Coarse grained, equigranular/ No fissility								
Comment (if any)	Shows sign of slight hydrothermal alteration								

Compiled by : T.Y. Irfan
SGE/EG, GCO

Date : 5.11.1987

CADAM - CLASSIFICATION and DESCRIPTION of AGGREGATE MATERIAL

LOCATION AND SAMPLE DETAILS	Quarry/Pit address : Pioneer Quarry Anderson Road, Kowloon Operator : Pioneer Sample : Type Blocks Size 50 kg Preparation Lab. crushed Supplied by EG Section	Grid Ref. 842310E 821320N Date of sampling	Date Rec'd Sampling Cert. No.

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Table 5 - Petrographic Evaluation of Granite Aggregates from the Pioneer Quarry (Fine-Grained Granite)

PETROGRAPHIC EVALUATION OF AGGREGATES

SAMPLE REF LOCATION/GRID REF SAMPLING DATE	3683 EG023 Pioneer Quarry (Anderson Road) 842310E 821320N	SAMPLE SIZE/WEIGHT Bulk sample : 50 kg Sub-sample : 1 kg (10-14 mm)
AGGREGATE PROPERTIES Particle Shape (BS 812:1975)	Angular to irregular	
Surface Texture (BS 812:1975)	Crystalline	
Coating	None	
Cleanliness (Dust etc)	Slightly dusty	
GEOLOGICAL PROPERTIES Rock Type (GSS Classification)	Fine-grained GRANITE (gf)	
Mineralogy		
Major Constituents	Quartz (33%), Feldspars (65%), Biotite (<1%)	
Minor Constituents	Pyrite (1%), Muscovite	
Cementing Materials	None	
Expansive Minerals	Pyrite may be deleterious	
Weathering of Particles	Generally fresh, some lightly discoloured (slightly decomposed). Yellowish brown staining around some pyrite crystals.	
Organic Material Content	None	
GENERAL COMMENTS	inequigranular fabric, grain size 0.1 to 2 mm, occasional megacrysts up to 6 mm.	Compiled by T.Y. Irfan Date 5.11.1987
ADDITIONAL INFORMATION		

Table 6 - Petrographic Evaluation of Granite Aggregates from the Pioneer Quarry (Fine- to Medium-Grained Granite)

PETROGRAPHIC EVALUATION OF AGGREGATES		
SAMPLE REF LOCATION/GRID REF SAMPLING DATE	3680 EG020 Pioneer Quarry (Anderson Road) 842310E 821320N	SAMPLE SIZE/WEIGHT Bulk Sample : 50 kg Sub-sample : 1 kg (10-14 mm)
AGGREGATE PROPERTIES Particle Shape (BS 812:1975)	Angular to irregular, few elongated	
Surface Texture (BS 812:1975)	Crystalline	
Coating	None	
Cleanliness (Dust etc)	Clean	
GEOLOGICAL PROPERTIES Rock Type (GSS Classification)	Fine- to medium-grained GRANITE (gfm)	
Mineralogy		
Major Constituents	Quartz (38%), Feldspars (60%), Biotite (<2%)	
Minor Constituents	Muscovite	
Cementing Materials	Crystalline, no cementing minerals	
Expansive Minerals	None	
Weathering of Particles	Generally fresh, a few grains are lightly discoloured (slightly decomposed). A few show signs of slight hydrothermal alteration	
Organic Material Content	None	
GENERAL COMMENTS	Equigranular with grain size 1 to 4 mm	Compiled by T.Y. Irfan Date 5.11.1987
ADDITIONAL INFORMATION		

Table 7 - Rock Index Properties of Fine- and Fine- to Medium-Grained Granites from the Pioneer Quarry

Rock Index Property			Fine-Grained Granite (Range)	Fine- to Medium-Grained Granite (Range)
Mineral Grain Specific Gravity,		g/cm^3	n.d.	n.d.
Bulk Density	Dry	g/cm^3	2.61 (2.61-2.62)	2.59 (2.59)
	Saturated	g/cm^3	2.62 (2.62-2.63)	2.60 (2.60)
Water Absorption		%	0.35 (0.33-0.36)	0.37 (0.37-0.38)
Porosity	Total	%	n.d.	n.d.
	Effective	%	0.90 (0.86-0.93)	0.97 (0.97-0.98)
Sonic Velocity		m/s	4518* (4300-4700)	3730* (3660-3850)
Point Load Strength		MPa	7.5+	7.10+ (4.5-11.5)

Legend :

n.d. Not determined.
\+ Mean of 15 to 30 tests on irregular lumps (ISRM, 1985).
* Determined on 75 mm diameter cores (ISRM, 1978).
other index tests - average of 3 to 5 tests on cores.

Table 8 - A Comparison of Aggregate Test Results from the Pioneer Quarry with British Standard and Other Acceptance Values

Aggregate Property+			Fine-Grained Granite	Fine- to Medium-Grained Granite	Acceptance Value	Use	Authority
Aggregate Crushing Value,	ACV	%	21	29	Max 30	C.R.	Higginbottom (1976)
Aggregate Impact Value,	AIV	%	15	27	Max 45[1] Max 30[2]	C.R. C.R.	BS882 : 1983 BS882 : 1983
Los Angeles Abrasion Value,	LAAV	%	28	44	Max 30[3] Max 40[4] Max 35[1]	C. C. R.	Australian Standard (1985) Australian Standard (1985) Shergold (1948)
Water Absorption		%	0.58	0.65	Max 3[1]	C.R.	Higginbottom (1976)
Flakiness Index,	I_F		26	13	Max 35[5]	C.R.	Higginbottom (1976)
Elongation Index,	I_E		31	44			

Notes :

1 - General use
2 - For wearing surfaces
3 - Difficult conditions
4 - Average conditions
5 - For C20 and over concrete grade

\+ - Average of 2 test results
C - Concrete aggregate
R - Road aggregate

Table 9 - Test Results on Laboratory Crushed Granitic Aggregates (10-14 mm)

Aggregate Property	Fine- to Medium Grained Granite Mau Yau Tong (Irfan, 1987a)	Medium-Grained Granite Turret Hill (Irfan & Nash, 1987)	Coarse-Grained Granite Lai King (Irfan, 1987c)	Monzonite Turret Hill (Irfan, 1987b)
Aggregate Crushing Value %	27	23	23	18
Aggregate Impact Value %	31	24	25	12
Los Angeles Abrasion Value %	43	29	31	21.5
Water Absorption %	0.4	0.5	0.3	0.5
Flakiness Index	13	7	11	20
Elongation Index	28	41	34	39

Table 10 - Aggregate Test Results from Anderson Road Quarries, 1975-1985 (from Choy & Irfan, 1986)

Aggregate Property		Ka Wah Quarry Granite	Pioneer Quarry Granite
Aggregate Crushing Value, ACV	%	30** (24-34)	28** (23-30)
Aggregate Impact Value, AIV	%	28 (19-33)	29 (25-34)
10% Fines Value	kN	145 (120-200)	125 (100-150)
Water Absorption,	%	0.6 (0.3-0.8)	0.7 (0.5-0.8)
Relative Density	g/cm^3	2.60 (2.58-2.62)	2.60 (2.57-2.61)
Flakiness Index, I_F		17 (10-27)	17 (13-22)
Elongation Index, I_E		35 (26-41)	34 (22-42)
Na_2SO_4 Soundness,	%	n.d.	n.d.

Legend :

n.d. Not determined, the number in brackets indicates range of values.

** Test results from 1975 to 1977, all other test results 1980-1985.

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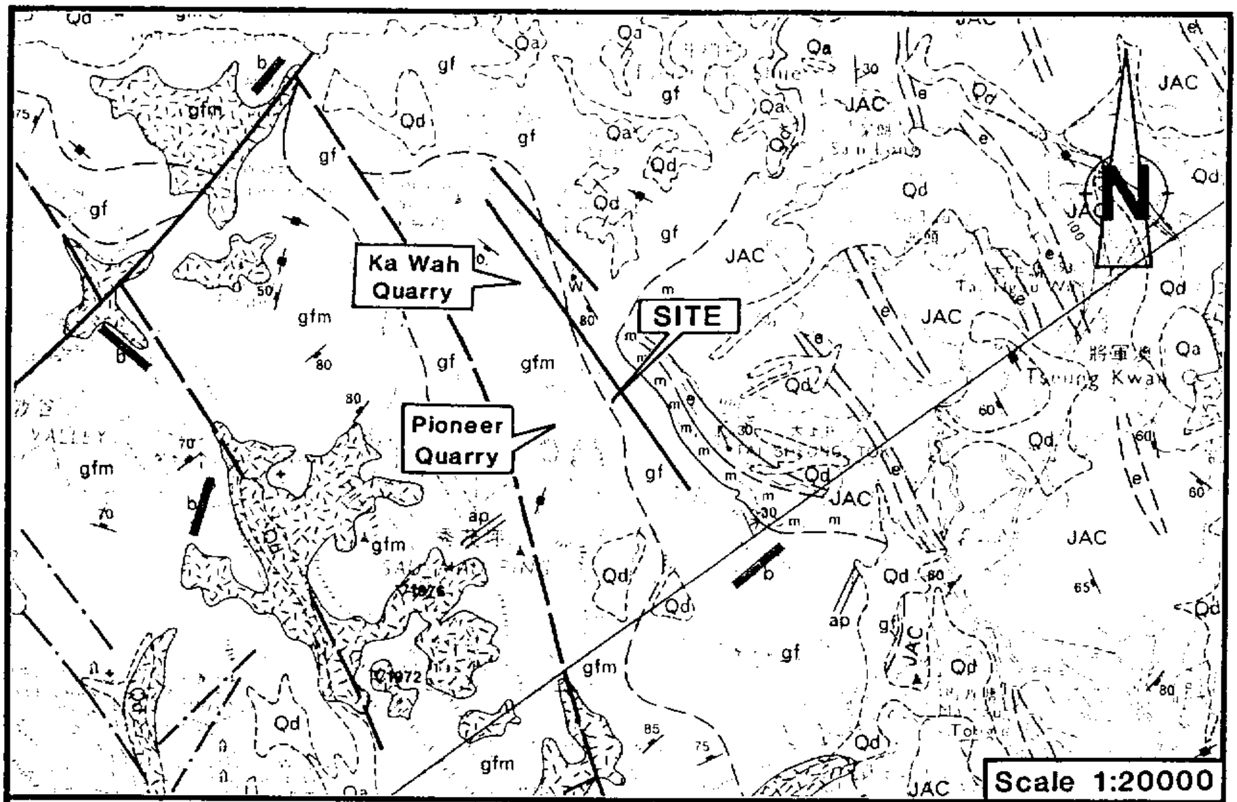

LEGEND :

SOLID GEOLOGY

- Qa, Qd — Quaternary Superficial Deposits (Onshore)
- m — Hornfels
- JAC — Fine Ash Vitric Tuff
- e — Eutaxite
- b — Basalt
- ap — Aplite
- gf — Fine-grained Granite, < 2mm
- gfm — Fine- to Medium-grained Granite
- gm — Medium-grained Granite, 2-6mm

GEOLOGICAL LINES

- Geological Boundary, Superficial Deposits
- Geological Boundary, Solid Rock
- Fault
- Photogeological Lineament

STRUCTURAL SYMBOLS

	Horizontal	Inclined	Vertical
Bedding	+	20	+
Flow Fabric	+	20	+
Jointing	+	20	+
Intrusive Contact		20	

MISCELLANEOUS SYMBOLS

- •W — Mineral Occurrence

NOTE : The geological map is extracted from the published sheet 11 of the 1 : 20000 geological map series of Hong Kong. Not all the geological symbols are given in the legend.

Figure 1 - Location Map Showing Geology of the Site and the Adjacent Areas

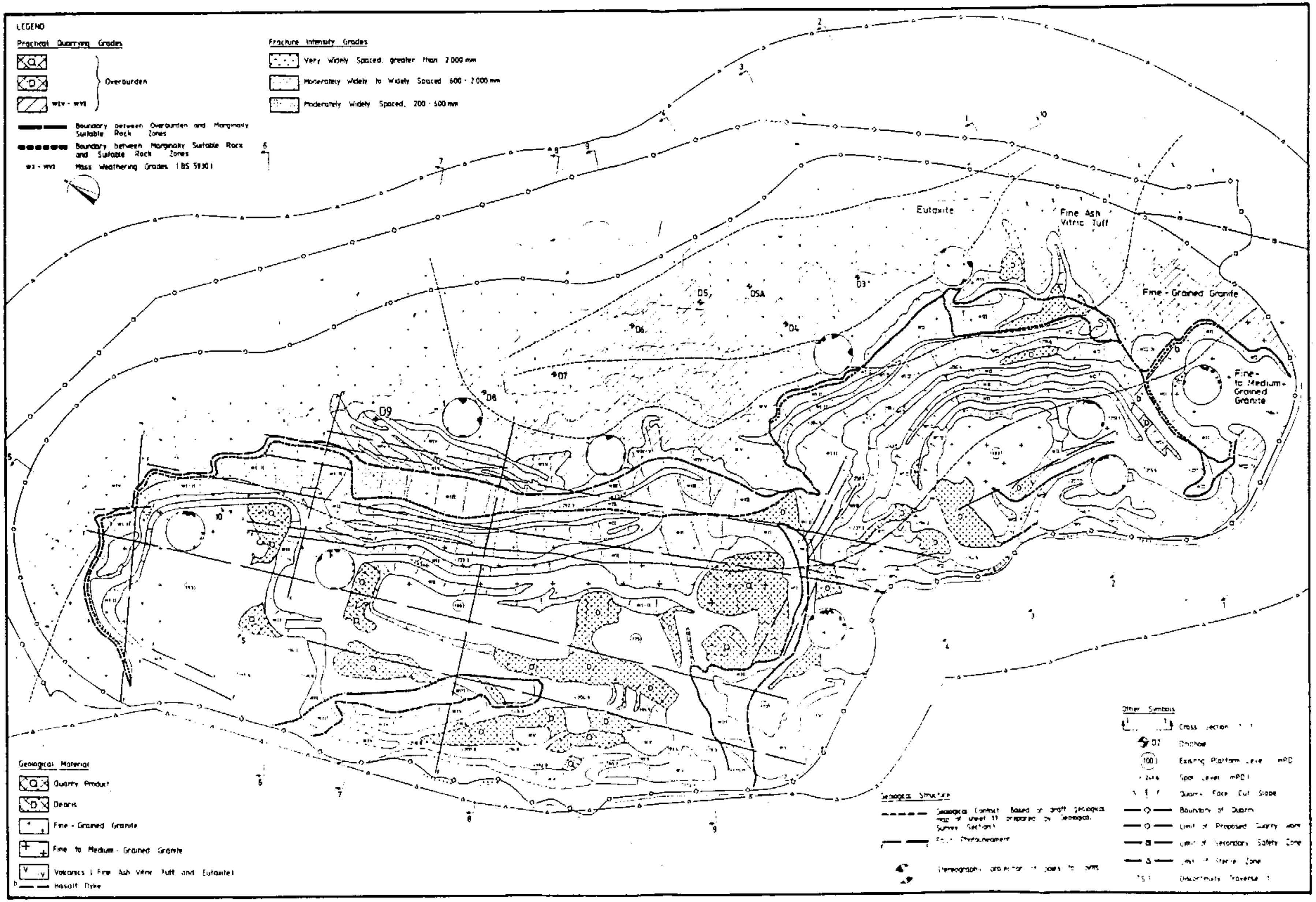

Figure 2 - Engineering Geological Map of the Anderson Road Quarries (from Choy & Irfan, 1986a)

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Plate 1 - Anderson Road Quarries

Plate 2 - The Sampling Locality

Plate 3 - Block Samples Being Selected From the Stockpile

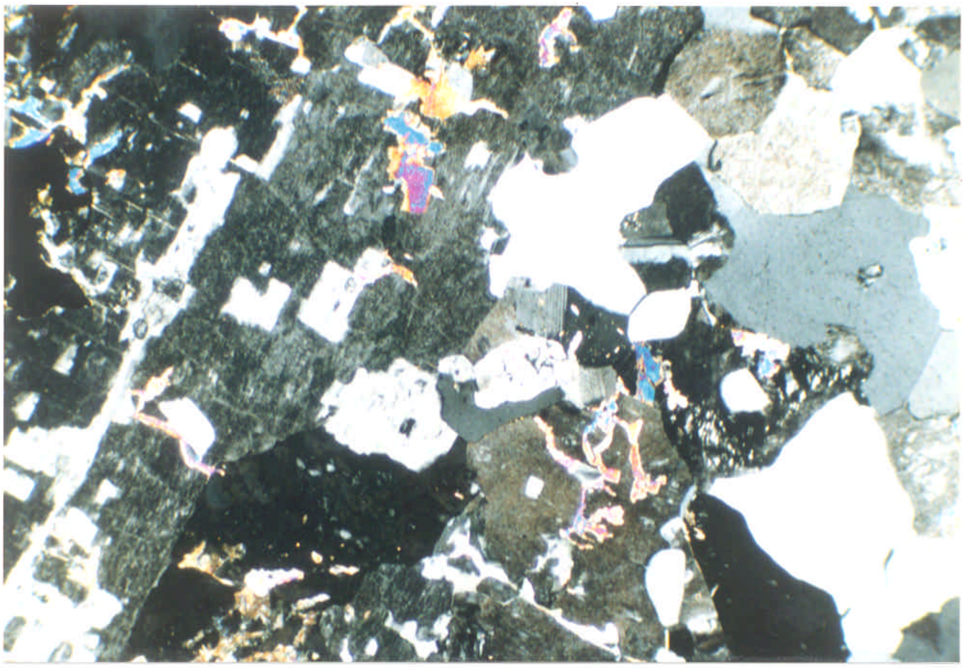

Plate 4 - Photomicrograph of Fine-Grained Granite Showing Inequigranular Texture, Partial Replacement of Feldspars by Muscovite. Large Grain on the Left Hand Side is Alkali Feldspar. Black Mineral Far Left is Pyrite (Cross Polarized Light - Enlarged Approximately 100 Times)

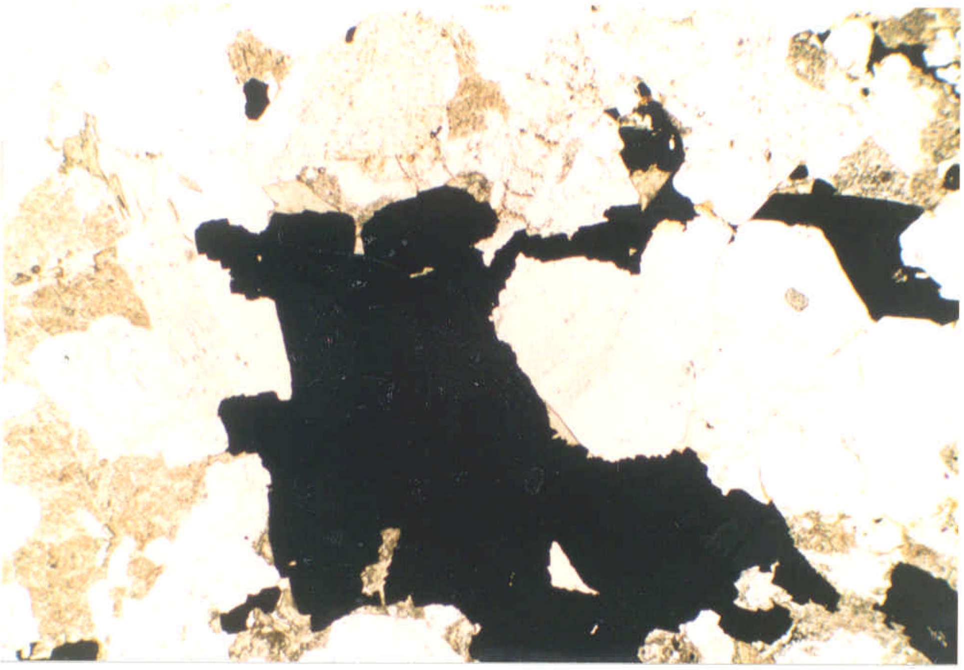

Plate 5 - Photomicrograph of Fine-Grained Granite, Showing Pyrite Grains (Plane Polarized Light - Enlarged Approximately 100 Times)

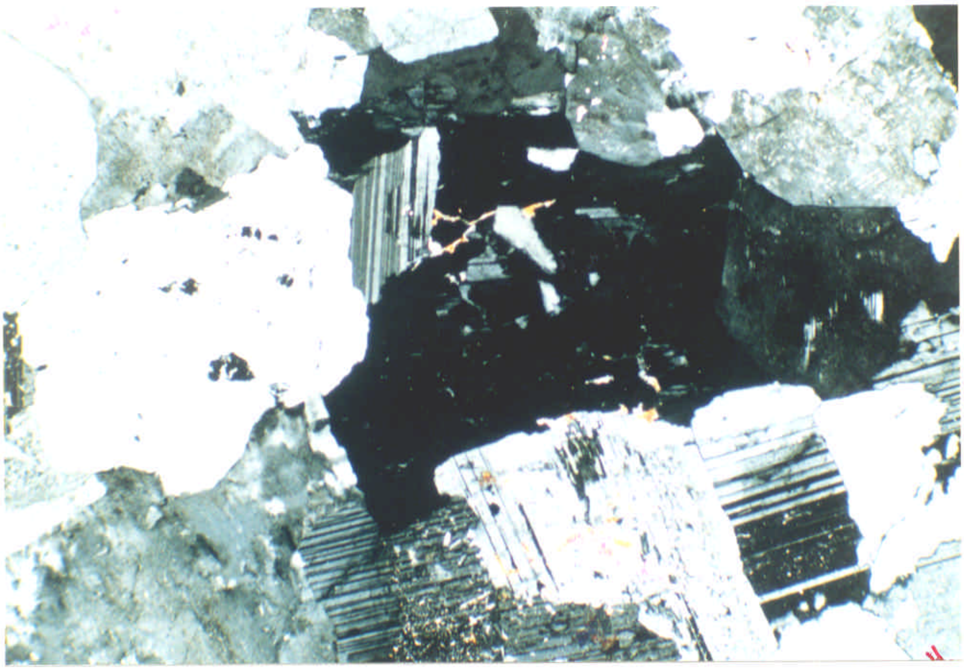

Plate 6 - Photomicrograph of Fine- to Medium- Grained Granite Showing Equigranular Texture and Alteration in Plagioclase Feldspars (Cross Polarized Light - Enlarged Approximately 100 Times)

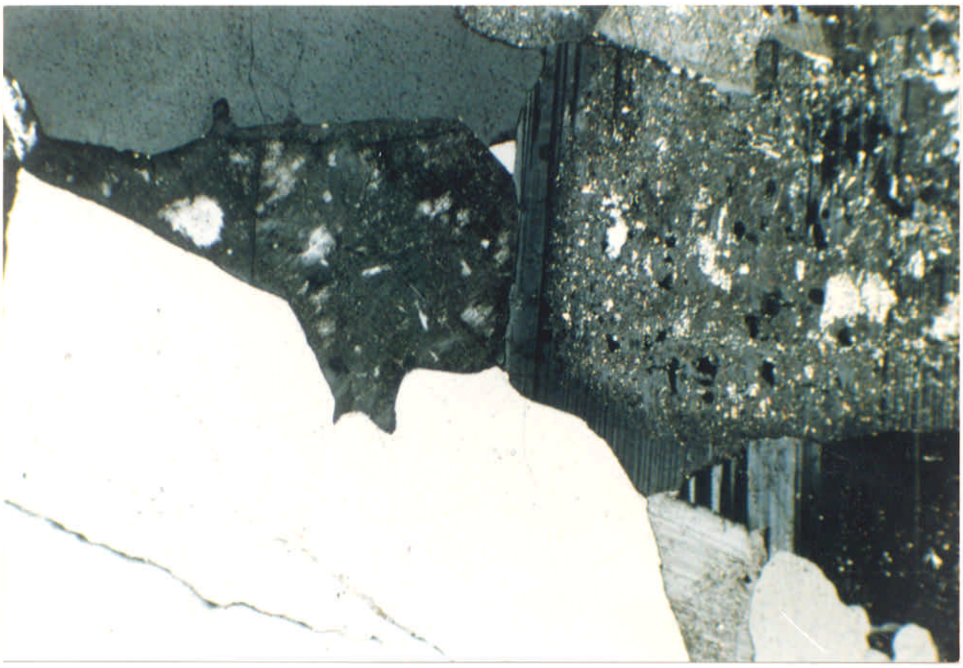

Plate 7a - Photomicrograph of Fine- to Medium Grained Granite Showing Transgranular Microcracks Through Quartz and Feldspar Grains. Plagioclase Feldspar (Right) is Partially Altered. K-feldspar (Centre) is Fresh (Enlarged Approximately 100 Times)

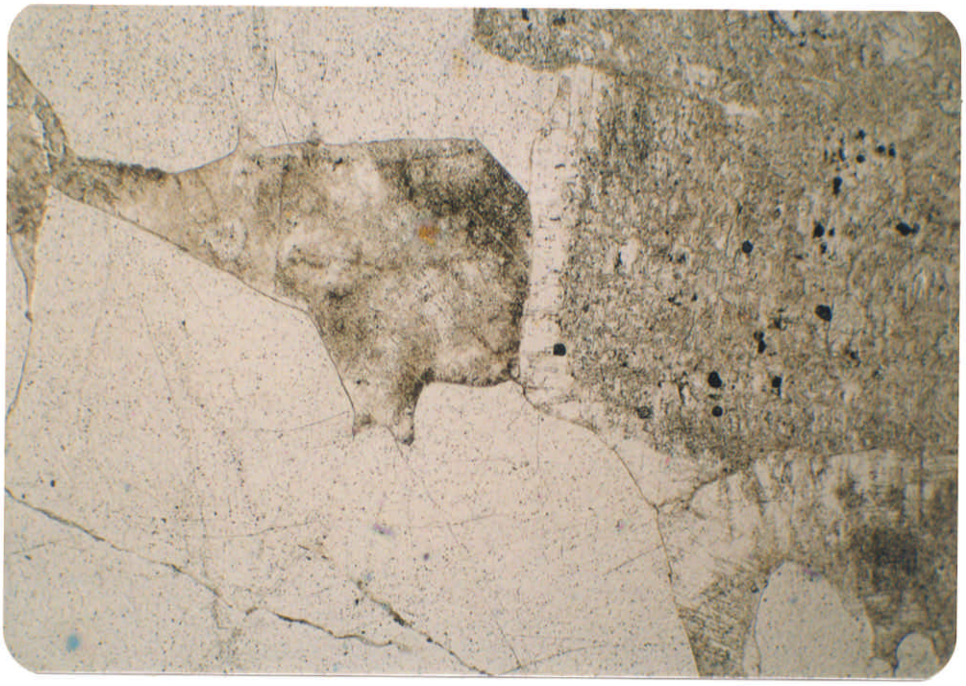

Plate 7b - Photomicrograph of Fine- to Medium-Grained Granite Showing Stained Grain Boundaries and Stained/Clean Transgranular Microcracks Plane Polarized Light - Enlarged Approximately 100 Times)

Fine-grained granite aggregate (10-14mm) Pioneer Quarry (EG023)

Plate 8 - Fine-Grained Granite Aggregate

Fine- to medium-grained granite aggregate (10-20mm) Pioneer Quarry (EG020)

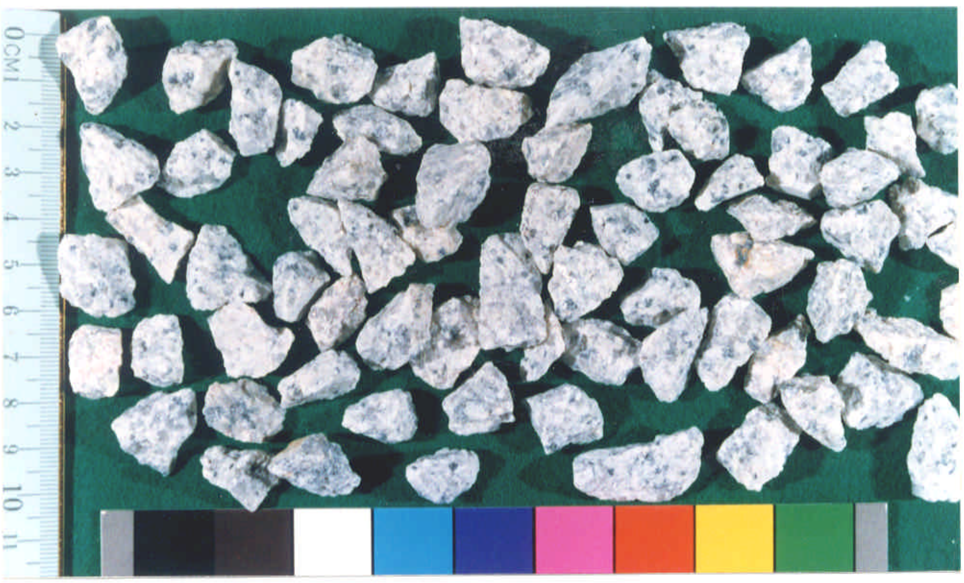

Plate 9 - Fine- to Medium-Grained Granite Aggregate