

**From:** Myron Fliegel  
**To:** Betty Garrett  
**Date:** 01/12/2007 1:30:12 PM  
**Subject:** Fwd: NRC request - cover material test results

Betty - please put this in ADAMS. Docket WM-110.

Thanks  
Mike

>>> "Donald Metzler" <[Donald.Metzler@gjo.doe.gov](mailto:Donald.Metzler@gjo.doe.gov)> 12/18/2006 9:43 AM >>>

Attached are the laboratory results for the geotechnical tests on the aggregate and riprap sources. These tests reports are dated July 13, September 22, and October 24, 2006. Please forward the reports to Ted Johnson as this was an action item from our site visit on December 5th and 6th.

Thanks,  
Don

**Mail Envelope Properties** (45A7D3B4.2CE : 1 : 10392)

**Subject:** Fwd: NRC request - cover material test results  
**Creation Date** 01/12/2007 1:30:12 PM  
**From:** Myron Fliegel

**Created By:** [MHF1@nrc.gov](mailto:MHF1@nrc.gov)

**Recipients**

nrc.gov  
 OWGWPO02.HQGWDO01  
 BSG (Betty Garrett)

**Post Office**

OWGWPO02.HQGWDO01

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nrc.gov

<b>Files</b>	<b>Size</b>	<b>Date &amp; Time</b>	
MESSAGE	1172	01/12/2007 1:30:12 PM	
TEXT.htm	2259		
7C_GEOTECHNICAL102406.PDF		81157	01/12/2007 1:29:14
PM			
7A_GEOTECHNICAL071306.PDF		73872	01/12/2007 1:29:14
PM			
7B_GEOTECHNICAL092206.PDF		744119	01/12/2007 1:29:17
PM			

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**Geotechnical  
Engineering  
Group, Inc.**

July 13  
~~February 23~~, 2006

**S.M Stoller Corporation  
2597 B ¼ Road  
Grand Junction, CO 81503**

**Attention: Mr. Craig Goodknight  
Senior Geologist**

**Subject: Geotechnical Testing Services  
Green River Gravel Pit  
GEG Job No. 2,417**

**Dear Mr. Sellers,**

As requested, Geotechnical Engineering Group, Inc. (GEG) has performed laboratory testing for the subject project. The laboratory tests were performed on samples obtained by others. Laboratory tests performed include bulk specific gravity tests presented on Table I, and Schmitt hammer tests presented on Table II.

### **Bulk Specific Gravity**

Bulk Specific Gravity and Absorption tests were determined for each sample received. Bulk Specific Gravity and Absorption samples were determined by others. Tests were performed in accordance with ASTM Test Method C127. The results of the Bulk Specific Gravity and Absorption determinations are presented on Table 1.

### **Schmidt Rebound Hammer**

Schmidt Rebound hammer results were determined for each sample received. Schmidt Hammer samples were determined by others. Tests were performed in accordance with ASTM Test Method C805. The results of the Schmidt Hammer tests are presented on Table 2.

Geotechnical, Environmental and Materials Testing Consultants  
Grand Junction - Montrose - Moab - Crested Butte  
(970) 245-4078 • fax (970) 245-7115 • [geotechnicalgroup.com](http://geotechnicalgroup.com)  
2308 Interstate Avenue, Grand Junction, Colorado 81505

We believe the laboratory study was performed and this letter was prepared in a manner consistent with that level of care and skill ordinarily used by geotechnical engineers practicing in this area at this time. No other warranty, either express or implied, is made. When we may be of further service or answer any questions from a geotechnical or construction materials point of view, please call.

Sincerely,  
**GEOTECHNICAL ENGINEERING GROUP, INC.**



**Corey Cooper**  
**Laboratory Supervisor**

CC:rwa  
(3 copies sent)

TABLE I

**SUMMARY OF LABORATORY TEST  
RESULTS**

<b>Sample Description</b>	<b>Bulk Specific Gravity</b>	<b>Absorbtion</b>
2"- 4" Quartzite	2.56	.302
2"- 4" Quartz/Chert	2.65	.057
2"- 4" Tan Sand Stone	2.39	.445
2"- 4" Red Sand Stone	2.61	.698
4"+ Sand Stone	2.62	.617
4"+ Quartzite	2.62	.362
4"+ Mottled Sand Stone	2.49	1.274
4"+ Orthoquartzite	2.51	1.201
4"+ Orthoquartzite Conglam.	2.51	1.686

## Schmidt Rebound Value Worksheet

**Table II**  
Schmidt Rebound Value Worksheet

Sample	Rebound #		Sample	Rebound #		Sample	Rebound #	
4"+ Quartzite			4"+ Sand Stone			4"+ Mottled Sand Stone		
1	58		1	44		1	33	
2	59		2	31	Discard	2	32	
3	58		3	44		3	46	
4	60		4	40		4	41	
5	61		5	34		5	36	
6	59		6	48		6	38	
7	60		7	45		7	32	
8	56		8	46		8	31	
9	56		9	32	Discard	9	27	
10	52		10	48		10	32	
avg	57.9		avg	41.2		avg	34.4	

Sample	Rebound #		Sample	Rebound #		Sample	Rebound #	
Orthoquartzite			Orthoquartzite Conglomerate					
1	61	Discard	1	58		1		
2	49		2	40	Discard	2		
3	56		3	55		3		
4	46		4	51		4		
5	52		5	54		5		
6	58		6	52		6		
7	49		7	54		7		
8	41	Discard	8	54		8		
9	58		9	46		9		
10	58		10	53		10		
avg	53.3		avg	53.9		avg		

Sample	Rebound #		Sample	Rebound #		Sample	Rebound #
1			1			1	
2			2			2	
3			3			3	
4			4			4	
5			5			5	
6			6			6	
7			7			7	
8			8			8	
9			9			9	
10			10			10	
avg			avg			avg	

Readings differing from the average of 10 readings by more than 6 units are discarded and not used in determination of the average.

If more than 2 readings differ from the average by 6 units, the entire set of readings is discarded and a new set of readings is determined at 10 new locations on sample.



October 24, 2006

**S.M. Stoller Corporation**  
2597 B ¼ Road  
Grand Junction, CO 81503

**Attention: Mr. Craig Goodknight**

**Subject: Geotechnical Testing Services**  
**Aggregate Sources**  
**Green River and Valley City Gravel Pits**  
**GEG Job No. 2,417**

**Dear Mr. Goodknight**

As requested, Geotechnical Engineering Group, Inc. (GEG) has performed laboratory testing services for the subject project. The laboratory tests were performed on samples obtained by others. Laboratory tests performed include Sodium Sulfate Soundness test and LA Abrasion test. The samples and tests performed were determined by SM Stoller Corporation. The Sodium Sulfate Soundness test was performed in general conformance with ASTM C88-05 and is presented on Figs. 1 and 2. LA Abrasion tests were performed by Trautner Geotech and are included in Appendix A.

We believe the laboratory study was performed and this letter was prepared in a manner consistent with that level of care and skill ordinarily used by geotechnical engineers practicing in this area at this time. No other warranty, either express or implied, is made. When we may be of further service or answer any questions from a geotechnical or construction materials point of view, please call.

Geotechnical, Environmental and Materials Testing Consultants  
Grand Junction - Montrose - Moab - Crested Butte  
(970) 245-4078 • fax (970) 245-7115 • [geotechnicalgroup.com](http://geotechnicalgroup.com)  
2308 Interstate Avenue, Grand Junction, Colorado 81505

Green River Gravel Pit  
GEG Job No. 2,417  
Page 2 of 7

Sincerely,  
GEOTECHNICAL ENGINEERING GROUP, INC.



Corey Cooper  
Engineering Assistant

CC:cb  
(3 copies sent)

**Soundness of Aggregates by Use of Sodium Sulfate ASTM: 88****Green River Gravel Pit**

<b>Soundness Test For Cours Aggregate</b>				
<b>Sieve Size</b>	<b>Grading of Original Sample %</b>	<b>Weight of Test Fractions Before Test</b>	<b>% Passing Designated Sieve After Test</b>	<b>Weighted Percentage Loss</b>
4"	50	6176.6	0	0
2"	50	6126.3	4.84	14.97
<b>Totals</b>	<b>100</b>			<b>14.97</b>

**Fig. 1**

**Soundness of Aggregates by Use of Sodium Sulfate ASTM: 88**

Valley City

<b>Soundness Test For Cours Aggregate</b>				
<b>Sieve Size</b>	<b>Grading of Original Sample %</b>	<b>Weight of Test Fractions Before Test</b>	<b>% Passing Designated Sieve After Test</b>	<b>Weighted Percentage Loss</b>
4"	100	7128.4	0	0
<b>Totals</b>	<b>100</b>			

Fig. 2



**TRAUTNER GEOTECH**  
A DIVISION OF TRIGON**L.A. ABRASION  
ASTM C535**

Grading \_1

After 100 revolutions percent (R100) loss	=	9.04%
After 200 total revolutions percent (R200) loss	=	12.35%
After 1000 total revolutions percent (1000)	=	24.14%
Ratio R200/R1000	=	0.51

*Sample Identification:* Green River Gravel Pit

PROJECT: GEG MISCELLANEOUS TESTING  
ENGINEERING TECHNICIAN: J. REICL  
PROJECT NUMBER: 50644MT  
DATE: OCTOBER 13, 2006  
LABORATORY NUMBER: 1350A

---

GEOTECHNICAL ENGINEERING, MATERIAL TESTING AND ENGINEERING GEOLOGY  
214 8000 DRIVE DURANGO, CO 81303 970-259-5095, 382-2515 FAX

**TRAUTNER GEOTECH**  
A DIVISION OF TRIGON**L.A. ABRASION  
ASTM C535**

Grading\_1

After 100 revolutions percent (R100) loss	=	5.03%
After 200 total revolutions percent (R200) loss	=	8.98%
After 1000 total revolutions percent (R1000)	=	25.06%
Ratio R200/R1000	=	0.36

*Sample Identification:* Valley City

PROJECT: GEG MISCELLANEOUS TESTING  
ENGINEERING TECHNICIAN: J. REICLE  
PROJECT NUMBER: 50644MT  
DATE: OCTOBER 13, 2006  
LABORATORY NUMBER: 12508

---

GEOTECHNICAL ENGINEERING, MATERIAL TESTING AND ENGINEERING GEOLOGY  
214 BODD DRIVE DURANGO, CO 81303 970-259-8095, 382-2515 FAX

**Geotechnical  
Engineering  
Group, Inc.**

September 22, 2006

**S.M. Stoller Corporation  
2597 B ¼ Road  
Grand Junction, CO 81503**

**Attention: Mr. Craig Goodknight**

**Subject: Geotechnical Testing Services  
Aggregate Sources  
Green River Gravel Pit  
GEG Job No. 2,417**

**Dear Mr. Goodknight**

As requested, Geotechnical Engineering Group, Inc. (GEG) has performed laboratory testing services for the subject project. The laboratory tests were performed on samples obtained by others. Laboratory tests performed include Sodium Sulfate Soundness test, Schmidt Rebound tests, Specific Gravity and Absorption tests, LA Abrasion test and Petrographic Examination. The samples and tests performed were determined by SM Stoller Corporation. The Sodium Sulfate Soundness test was performed in general conformance with ASTM C88-05 and is presented on Fig. 1. Schmidt Rebound test results are presented on Fig. 2. Specific Gravity and Absorption tests were performed in general conformance with ASTM C127 and are presented on Fig. 3. LA Abrasion tests were performed by Trautner Geotech and are included in Appendix A. Petrographic Examination was performed by DRP Consulting, Inc., and is included in Appendix B.

We believe the laboratory study was performed and this letter was prepared in a manner consistent with that level of care and skill ordinarily used by geotechnical engineers practicing in this area at this time. No other warranty, either express or implied, is made. When we may be of further service or answer any questions from a geotechnical or construction materials point of view, please call.

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2308 Interstate Avenue, Grand Junction, Colorado 81505

Sincerely,  
**GEOTECHNICAL ENGINEERING GROUP, INC.**



**Corey Cooper**  
**Engineering Assistant**

Reviewed by:



**Michael Fortner**  
**Laboratory Supervisor**

CC:MF:cb  
(3 copies sent)

**Soundness of Aggregates by Use of Sodium Sulfate ASTM: 88**

<b>Soundness Test For Cours Aggregate</b>				
<b>Sieve Size</b>	<b>Grading of Original Sample %</b>	<b>Weight of Test Fractions Before Test</b>	<b>% Passing Designated Sieve After Test</b>	<b>Weighted Percentage Loss</b>
4"	76	7036.2g	0	0
2"	24	2170.3g	1.2	4.8
<b>Totals</b>	<b>100</b>			<b>4.8</b>

**Fig. 1**

## Schmidt Rebound Value Worksheet

Sample		Sample		Sample	
4"+ Quartzite		4"+ Sand Stone		4"+ Mottled Sand Stone	
	Rebound #		Rebound #		Rebound #
1	58	1	44	1	33
2	59	2	31	2	32
3	58	3	44	3	46
4	60	4	40	4	41
5	61	5	34	5	36
6	59	6	48	6	38
7	60	7	45	7	32
8	56	8	46	8	31
9	56	9	32	9	27
10	52	10	48	10	32
avg	57.9	avg	41.2	avg	34.4

Sample		Sample		Sample	
Orthoquartzite		Orthoquartzite Conglomerate			
	Rebound #		Rebound #		Rebound #
1	61	1	58	1	
2	49	2	40	2	
3	56	3	55	3	
4	46	4	51	4	
5	52	5	54	5	
6	58	6	52	6	
7	49	7	54	7	
8	41	8	54	8	
9	58	9	46	9	
10	58	10	53	10	
avg	53.3	avg	53.9	avg	

Sample		Sample		Sample	
	Rebound #		Rebound #		Rebound #
1		1		1	
2		2		2	
3		3		3	
4		4		4	
5		5		5	
6		6		6	
7		7		7	
8		8		8	
9		9		9	
10		10		10	
avg		avg		avg	

Readings differing from the average of 10 readings by more than 6 units are discarded and not used in determination of the average.

If more than 2 readings differ from the average by 6 units, the entire set of readings is discarded and a new set of readings is determined at 10 new locations on sample.

Fig. 2

## SUMMARY OF LABORATORY TEST RESULTS

Sample Description	Bulk Specific Gravity	Absorbtion
2" - 4" Quartzite	2.56	.302
2" - 4" Quartz/Chert	2.65	.057
2" - 4" Tan Sand Stone	2.39	.445
2" - 4" Red Sand Stone	2.61	.698
4"+ Sand Stone	2.62	.617
4"+ Quartzite	2.62	.362
4"+ Mottled Sand Stone	2.49	1.274
4"+ Orthoquartzite	2.51	1.201
4"+ Orthoquartzite Conglam.	2.51	1.686

Fig. 3

**APPENDIX A**

**L.A. ABRASION  
ASTM C535**

Grading 1

After 100 revolutions percent (R100) loss	=	3.13%
After 200 revolutions percent (R200) loss	=	5.88%
After 1000 total revolutions percent (1000) loss	=	18.47%
Ratio R200/R1000	=	0.32

*Sample Identification:* Variety of Cobbles, Delivered by Client

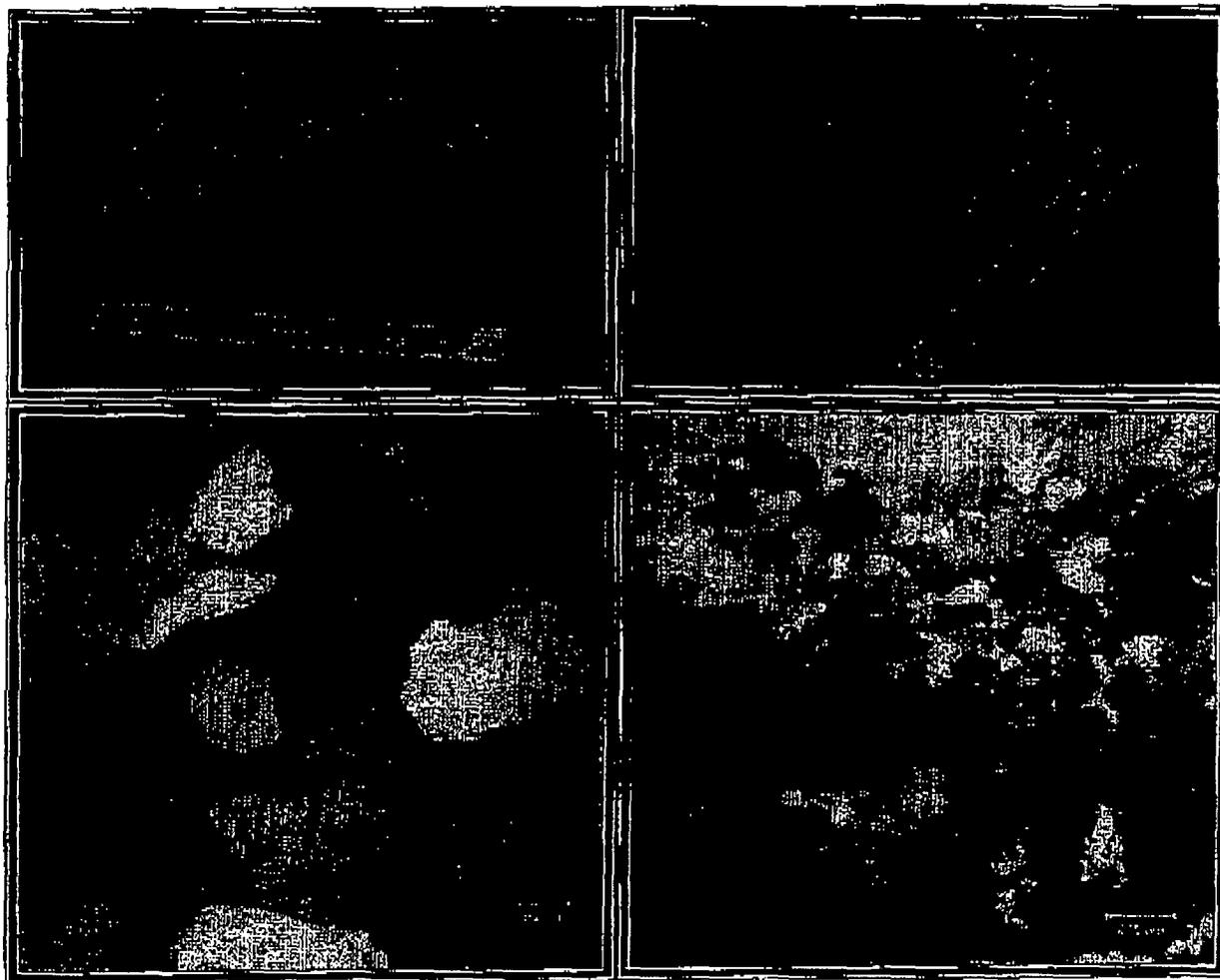
PROJECT: GEOTECHNICAL ENGINEERING GROUP  
PROJECT NUMBER: 50644MT  
DATE: 7/31/06  
LABORATORY NUMBER: 1291A

**APPENDIX B**

DRP CONSULTING, INC.  
PETROGRAPHIC ANALYSIS & CONSULTATION  
3200 CARBON PLACE • SUITE 104A • BOULDER, CO 80301 USA  
TEL: 303.938.0166 • FAX: 303.938.0167 • petro@drpcinc.com • www.drpcinc.com

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## ANALYSIS OF ROCK SAMPLES FROM GREEN RIVER TERRACE DEPOSITS NEAR MOAB, UTAH



**Prepared for:** Mr. Mike Fortner  
Geotechnical Engineering Group, Inc.  
Grand Junction, Colorado

**Prepared by:** David Rothstein, Ph.D., R.G.  
**Report No.:** DRP06.309

1 SEPTEMBER 2006

## 1.0 INTRODUCTION

Pursuant to the request of Mr. Mike Fortner of the Geotechnical Engineering Group, Inc. (GEG) located in Grand Junction, Colorado the purpose of the investigation is to assess the engineering properties of rock samples proposed for use as rip rap. DRP Consulting, Inc. (DRP) received six (6) rock samples from (GEG) on 11 July 2006 and was authorized and paid to proceed with the analysis of the samples on 31 July 2006. The samples are listed below in Table 1. GEG indicated that the primary interest in conducting the analyses was to assess the occurrence of clay minerals and the amount of weathering in the materials represented by the samples.

Table 1. List of Samples

GEG Sample ID	DRP No.
4" + Q	10YD2441
4" + SS	10YD2442
2" + Q	10YD2443
2" + RS	10YD2444
2" TS	10YD2445
2" QC	10YD2446

## 2.0 SCOPE OF WORK

The investigation involved microscopical analysis of the samples. This report summarizes the main findings of this investigation. Appendices A-F give specific information on each sample.

## 3.0 PROCEDURES

*Petrographic Analysis* The rocks were photographed in their as-received condition, described, and cut into slabs with a water-cooled saw. The slabs were lapped on polished using diamond-embedded wheels and an aqueous lubricant/coolant. Thin sections were prepared at Spectrum Petrographics in Vancouver Washington. The samples were examined with a stereomicroscope capable of a 3-180x magnification range and a petrographic microscope capable of 50-500x magnification range. The rocks were examined to obtain a geologic description, estimate of the modal mineralogy, to assess the presence of clay minerals and evaluate the weathering of the rock. The modal mineralogy was estimated visually on the basis of thin section examination. The weathering was assessed using the classification scheme of the International Society of Rock Mechanics.

**4.0 FINDINGS**

The following summarizes the findings from this investigation regarding the materials represented by the samples:

1. The rocks are hard and competent.
2. The rocks generally are fresh, with only slight weathering in two rocks. The weathering involves staining on one rock and the presence of cracks associated with sericite and minor clay mineralization.
3. There is no significant clay mineralization in any of the materials represented by the samples. Some rocks contain more than trace amounts of clay minerals and physical testing to assess their resistance to freeze-thaw cycles is recommended to assess their durability if they are to be placed in a freeze-thaw environment.

Table 2 provides a brief summary of the results:

Table 2. Summary of Results				
GEG No.	DRP No.	Rock Name	Clay Minerals	Weathering
4" + Q	10YD2441	Very fine-grained quartz arenites	None	Fresh
4" + SS	10YD2442	Very fine-grained calcareous greywacke	3%	Fresh
2" + Q	10YD2443	Chert	None	Fresh
2" + RS	10YD2444	Red sandstone	None	Fresh
2" TS	10YD2445	Medium-grained bioclastic wackestone	5%	Slight
2" QC	10YD2446	Alkali granite pegmatite	Trace	Slight

This concludes work performed on this project to date.



David Rothstein, Ph.D., P.G.

APPENDIX A: Green River Aggregate  
 Sample ID: 4" + G (10YD2441)

Report No. DRP06\_309  
 Date: 31 August 2006

1. RECEIVED CONDITION	
ROCK NAME	Very fine-grained quartz arenite
DIMENSIONS & SURFACES	Rounded cobble is ovoid in shape. Cobble has a very smooth outer surface. Color of fresh surface is brown (10YR/5/3).
GENERAL COMMENT	The sample is hard and intact with no macroscopic cracks. Minor sand coating adheres to parts of sample.

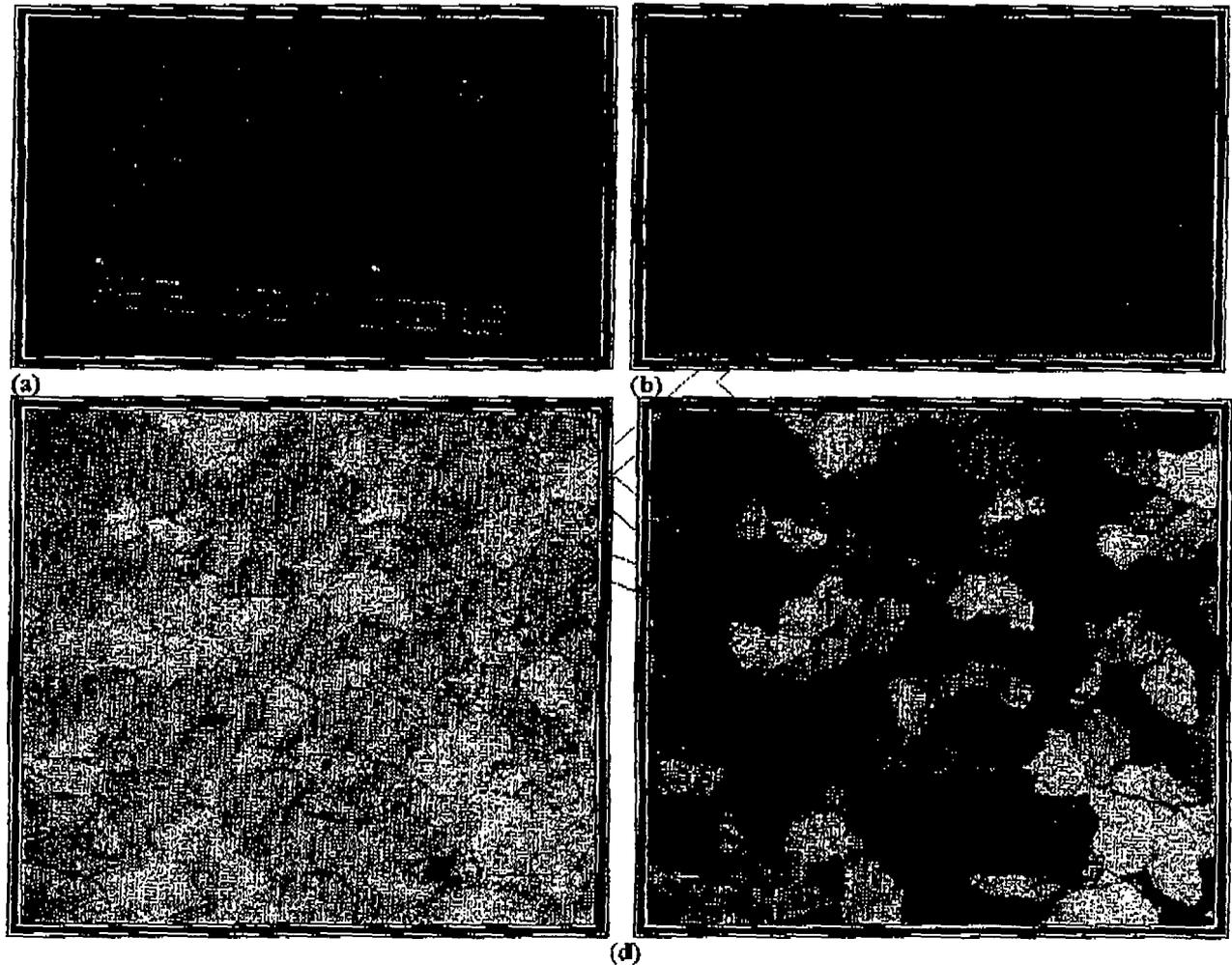
2. PETROGRAPHIC OVERVIEW	
MINERALOGY/MODE	Quartz: 72% Feldspar: 3% Hematite: 3% Clay minerals: not observed  Siliceous Cement: 22%
TEXTURE	Well sorted, fine-grained quartz arenite. Rounded grains of quartz; tabular feldspar. Hematite as intergranular coatings. Siliceous cement with optical continuity on adjacent grains.
WEATHERING	Rock is fresh in ISRM classification with no sign of weathering.

3. COMMENTS	
The porosity and induration of this rock probably varies in a given formation; various engineering tests will be needed to determine the suitability of the material for a given application. In addition to physical tests such as LA abrasion, various reactivity tests are recommended to determine if the rock would be suitable for use as a concrete aggregate.	

APPENDIX A: Green River Aggregate  
 Sample ID: 4" + Q (10YD2441)

Report No. DRP06.309  
 Date: 31 August 2006

**FIGURES**



**Figure A1. Photographs of sample. (a) As-received condition. (b) Polished cross section cut through rock; scale at bottom in millimeters. (c) Plane-polarized transmitted light photomicrograph of thin section. (d) Cross-polarized transmitted light photomicrograph of thin section.**

APPENDIX B: Green River Aggregate  
 Sample ID: 4" + 55 (10YD2442)

Report No. DRP06.309  
 Date: 31 August 2006

1. RECEIVED CONDITION	
ROCK NAME	Very fine-grained calcareous greywacke
DIMENSIONS & SURFACES	Flattened cobble with rounded edges and smooth surface. Maximum dimensions 110 mm (4 3/8 in.) by 25 mm (1 in.). Pale brown color (10YR/6/3).
GENERAL COMMENT	Rock is hard and competent and was received with no fractures. A fine sand coats parts of sample.

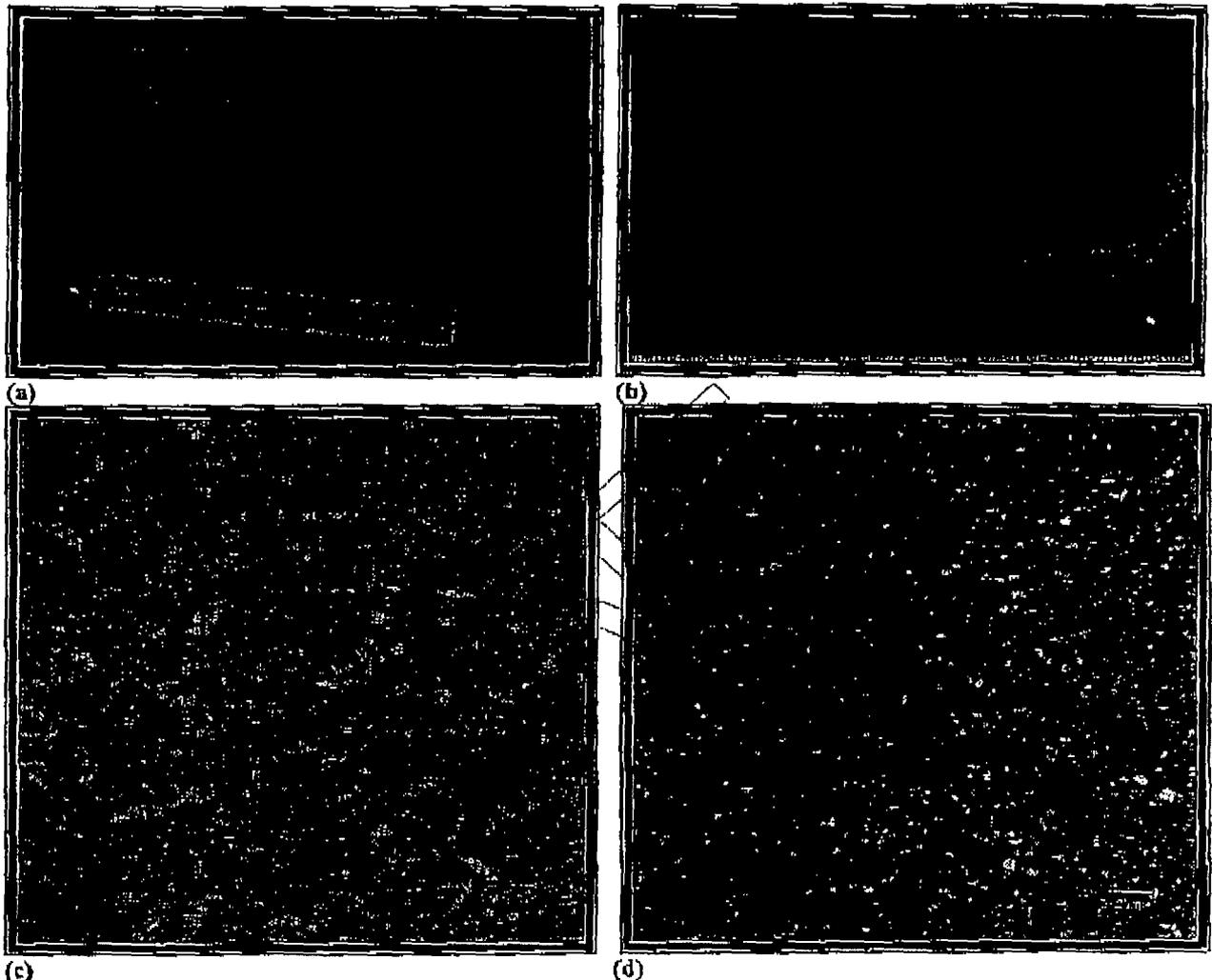
2. PETROGRAPHIC OVERVIEW	
MINERALOGY/MODE	Quartz: 35% Calcite: 30 Hematite: 7% Clay minerals: 3% Chlorite, feldspar in trace amounts  Calcareous Cement: 25%
TEXTURE	Moderately sorted, fine-grained quartz particles are subangular to subrounded and are typically elongated.  Hematite present as medium-grained particles and also as intergranular coating on quartz grains.  Calcite cement fills interstitial areas. Very low porosity (< 2%)
WEATHERING	Rock is fresh in ISRM classification with no sign of weathering.

3. COMMENTS	
The porosity and induration of the rock may vary in a given formation; various engineering tests will be needed to determine the suitability of the material for a given application. In addition to physical tests such as LA abrasion, various reactivity tests are recommended to determine if the rock would be suitable for use as a concrete aggregate.	

APPENDIX B: Green River Aggregate  
Sample ID: 4" + SS (10YD2442)

Report No. DRP06.309  
Date: 31 August 2006

**FIGURES**



**Figure B1. Photographs of sample. (a) As-received condition. (b) Polished cross section cut through rock; scale at bottom in millimeters. (c) Plane-polarized transmitted light photomicrograph of thin section. (d) Cross-polarized transmitted light photomicrograph of thin section.**

APPENDIX C: Green River Aggregate  
 Sample ID: 2" G (10YD2443)

Report No. DRP06.309  
 Date: 31 August 2006

1. RECEIVED CONDITION	
ROCK NAME	Chert
SHAPE & SURFACES	Cobble has flattened side and ovoid/dome shaped. Pale brown color (10YR/6/3). Minor white/buff calcareous coating on portions of cobble.
GENERAL COMMENT	Sample received with no fractures. Minor sand coating adheres to parts of sample.

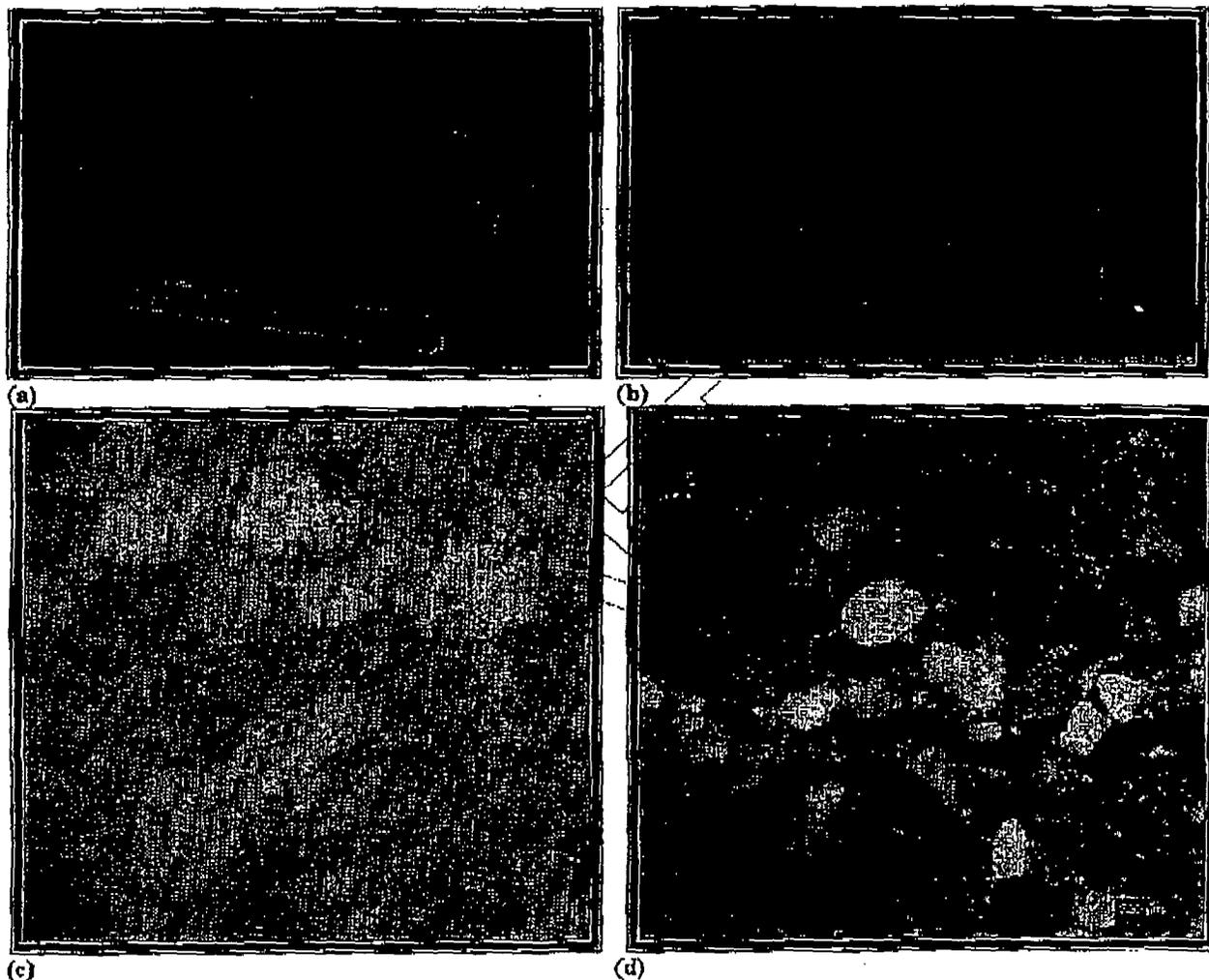
2. PETROGRAPHIC OVERVIEW	
MINERALOGY/MODE	Monocrystalline Quartz: 70% Polycrystalline quartz: 2% Chalcedonic cement: 27% Calcite + hematite: 1%  Clay minerals: none observed
TEXTURE	Well sorted, rounded quartz grains with chalcedonic chert cement binding quartz grains.  Rock shows weak bedding planes defined primarily by alignment of hematite along grain boundaries. o
WEATHERING	Rock is fresh in ISRM classification with no sign of weathering.

**3. COMMENTS**  
 The porosity and induration of this rock is probably fairly consistent in a given formation; but various engineering tests are still needed to determine the suitability of the material for a given application. Chalcedonic chert tends to be highly reactive for alkali-silica reaction so this rock is not suitable for use as a concrete aggregate unless significant measures are taken to mitigate its potential reactivity.

APPENDIX C: Green River Aggregate  
 Sample ID: 2" Q (10YD2443)

Report No. DRP06.309  
 Date: 31 August 2006

**FIGURES**



**Figure C1. Photographs of sample. (a) As-received condition. (b) Polished cross section cut through rock; scale at bottom in millimeters. (c) Plane-polarized transmitted light photomicrograph of thin section. (d) Cross-polarized transmitted light photomicrograph of thin section.**

APPENDIX D: Green River Aggregate  
 Sample ID: 2" RS (10YD2444)

Report No. DRP06.309  
 Date: 31 August 2006

1. RECEIVED CONDITION	
ROCK NAME	Red sandstone
SHAPE & SURFACES	Ovoid-shaped cobble, rounded with smooth surface; dark red (2.5YR/3/6) color.
GENERAL COMMENT	Rock is hard and competent and was received with no macroscopic fractures.

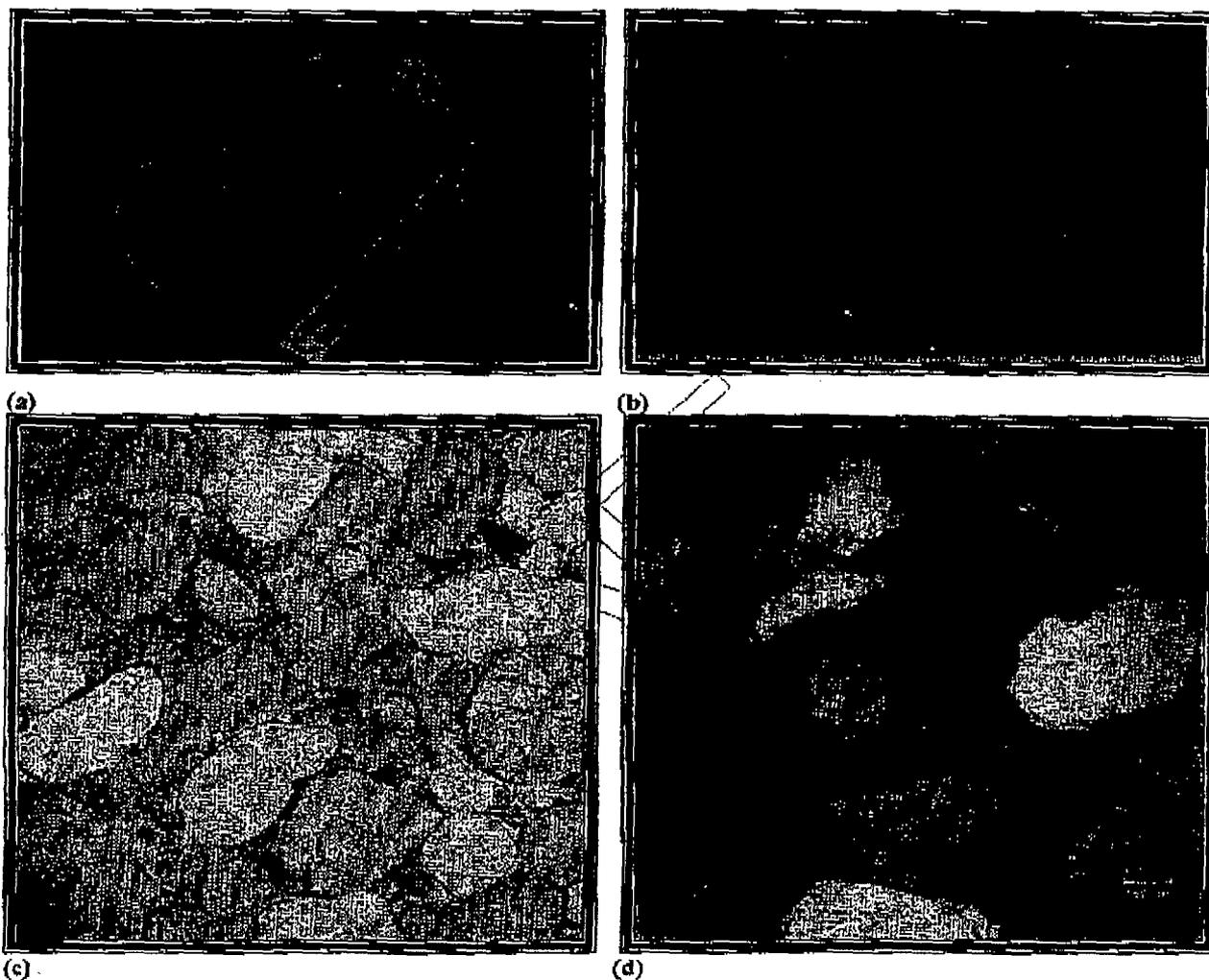
2. PETROGRAPHIC OVERVIEW	
MINERALOGY/MODE (EXCLUSIVE OF POROSITY)	Quartz: 75% Feldspar: 15% Silica cement: 7% Hematite: 3%  Clay minerals: none observed
TEXTURE	Well sorted, well rounded quartz and feldspar grains with quartz-hematite cement.  Most of the quartz is monocrystalline; some polycrystalline and chert fragments are also present. Quartz is mostly clear but some cloudy grains are present. Minor sericitic alteration in feldspar. Some quartz grains show optical continuity with siliceous cement.  Hematite present primarily as coating on quartz and feldspar; some distinct crystals are also present at granular interstices.  Rock shows low porosity (~ 4%). In hand sample banding is present that is repeated every 7-10 mm (0.28-0.40 in.).
WEATHERING	Rock is fresh in ISRM classification.

3. COMMENTS	
The porosity and induration of this rock probably varies in a given formation; various engineering tests will be needed to determine the suitability of the material for a given application. In addition to physical tests such as LA abrasion, various reactivity tests are recommended to determine if the rock would be suitable for use as a concrete aggregate.	

APPENDIX D: Green River Aggregate  
Sample ID: 2" RS (10YD2444)

Report No. DRP06.309  
Date: 31 August 2006

**FIGURES**



**Figure D1. Photographs of sample. (a) As-received condition. (b) Polished cross section cut through rock; scale at bottom in millimeters. (c) Plane-polarized transmitted light photomicrograph of thin section. (d) Cross-polarized transmitted light photomicrograph of thin section.**

APPENDIX E: Green River Aggregate  
 Sample ID: 2" RS (10YD2445)

Report No. DRP06.309  
 Date: 31 August 2006

1. RECEIVED CONDITION	
ROCK NAME	Medium-grained bioclastic wackestone.
SHAPE & SURFACES	Elongated ovoid cobble, flattened on one side, relatively smooth surface.
GENERAL COMMENT	Sample received with no fractures. Rock weathers to reveal thin laminations but no partings observed.

2. PETROGRAPHIC OVERVIEW	
MINERALOGY/MODE (EXCLUSIVE OF POROSITY)	Calcite cement: 50% Bioclastic fragments: 35% Quartz: 7% Hematite: 3% Feldspar: 2%  Clay minerals: 5%
TEXTURE	Moderately sorted wackestone with micritic cement. Rock is thinly laminated on scale of 1-2 mm thick laminae.  Coarse grained bioclastic fragments consist mainly of mollusk fragments. Quartz and feldspar present as subangular, moderately elongated fragments. Hematite is present as intergranular platy grains that follow lamination surfaces. Some hematite is present as relatively equant crystals.  Clay minerals appear along lamination surfaces and are associated with hematite.
WEATHERING	Rock is slightly weathered in ISRM classification with slight discoloration and discontinuities.

3. COMMENTS	
The porosity and induration of this rock probably varies in a given formation so various engineering tests will be needed to determine the suitability of the material for a given application. In addition to physical tests such as LA abrasion, various reactivity tests are recommended to determine if the rock would be suitable for use as a concrete aggregate.	

APPENDIX E: Green River Aggregate  
Sample ID: 2" RS (10YD2445)

Report No. DRP06.309  
Date: 31 August 2006

## FIGURES

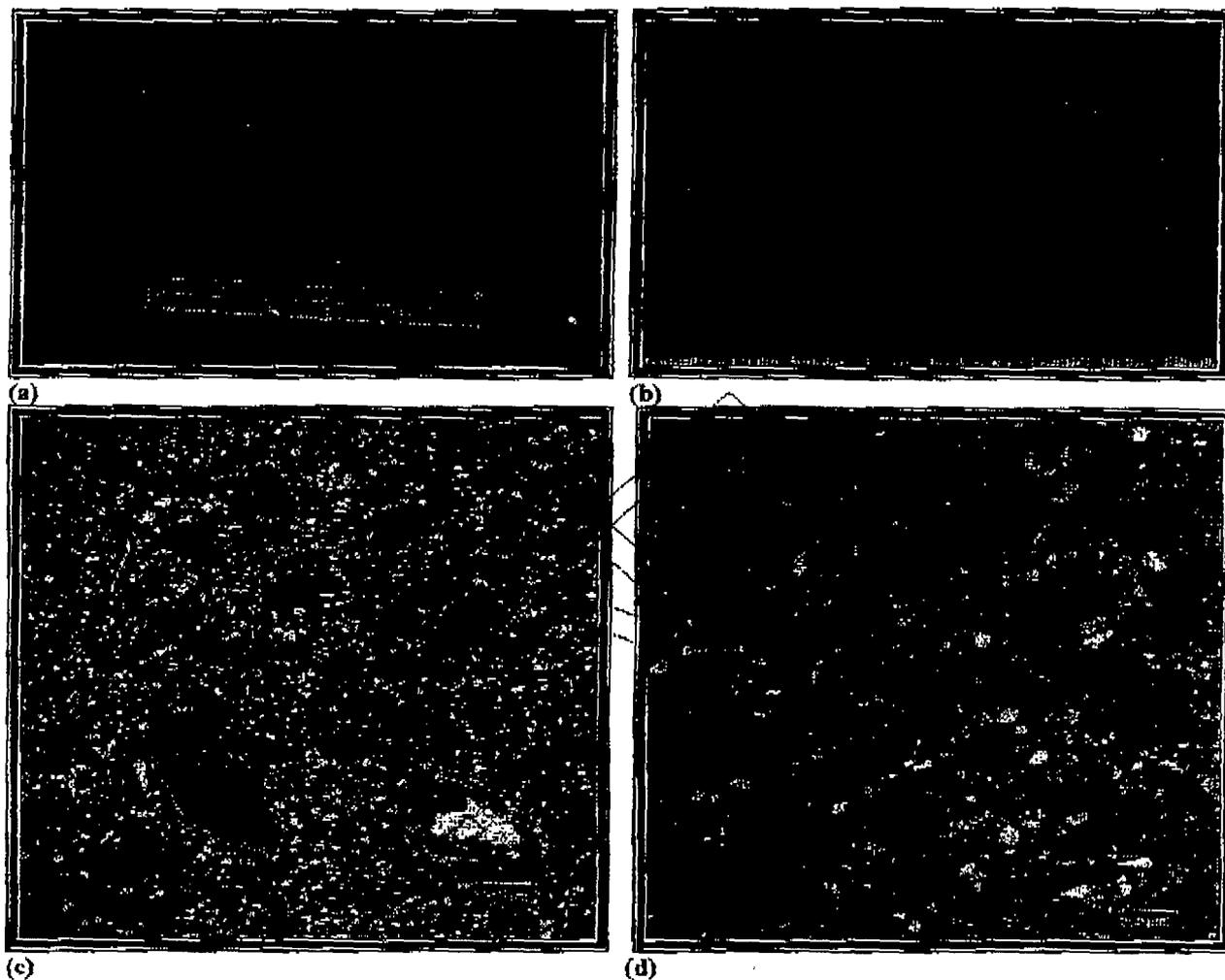


Figure E1. Photographs of sample. (a) As-received condition. (b) Polished cross section cut through rock; scale at bottom in millimeters. (c) Plane-polarized transmitted light photomicrograph of thin section. (d) Cross-polarized transmitted light photomicrograph of thin section.

APPENDIX F: Green River Aggregate  
 Sample ID: 2" QC (10YD2446)

Report No. DRP06.309  
 Date: 31 August 2006

### 1. RECEIVED CONDITION

ROCK NAME	Alkali granite pegmatite
SHAPE & SURFACES	Ovoid cobble, flattened on one side, relatively smooth surface.
GENERAL COMMENT	Sample is hard and competent and presents several hairline cracks that run through the full thickness of rock.

### 2. PETROGRAPHIC OVERVIEW

MINERALOGY/MODE (EXCLUSIVE OF POROSITY)	Quartz: 55% Alkali feldspar: 40% Plagioclase feldspar: 3% Hematite: 1% Muscovite: 1%  Clay minerals: trace
TEXTURE	Coarse-grained rock with intergrowth texture showing consertial relation of quartz and alkali feldspar. Some crystals consist of fine-grained intergrowths and complex sub-granular boundaries. There is considerable microcracking but no significant macroscopic cracks.
WEATHERING	Rock is slightly weathered in ISRM classification with slight sericitic alteration along microcracks and cleavage planes.

### 3. COMMENTS

The porosity and induration of this rock is probably fairly consistent but the extent of cracking may vary considerably. Various engineering tests will be needed to determine the suitability of the material for a given application. In addition to physical tests such as LA abrasion, various reactivity tests are recommended to determine if the rock would be suitable for use as a concrete aggregate.

APPENDIX F: Green River Aggregate  
Sample ID: 2" GC (10YD2446)

Report No. DRP06.309  
Date: 31 August 2006

## FIGURES

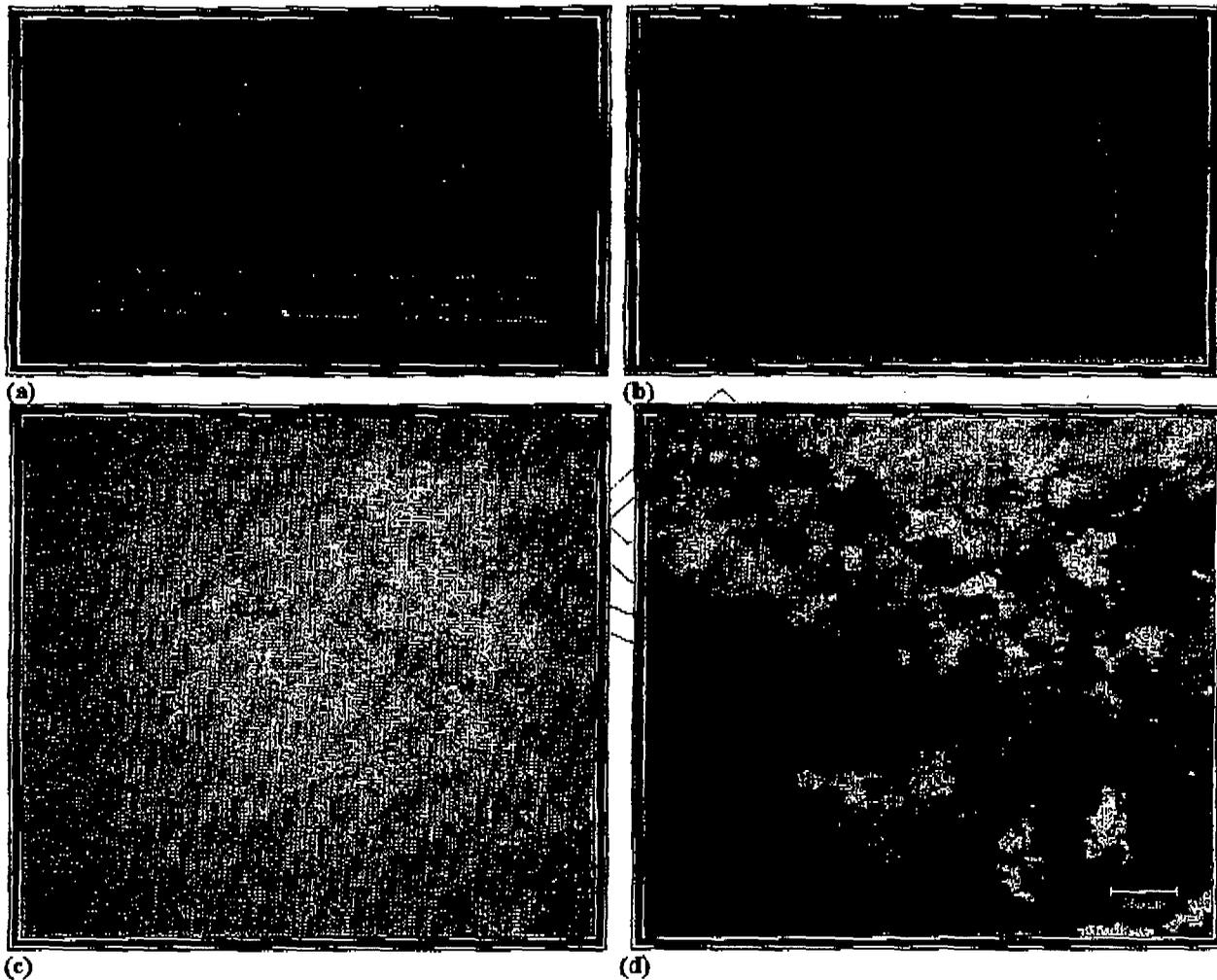
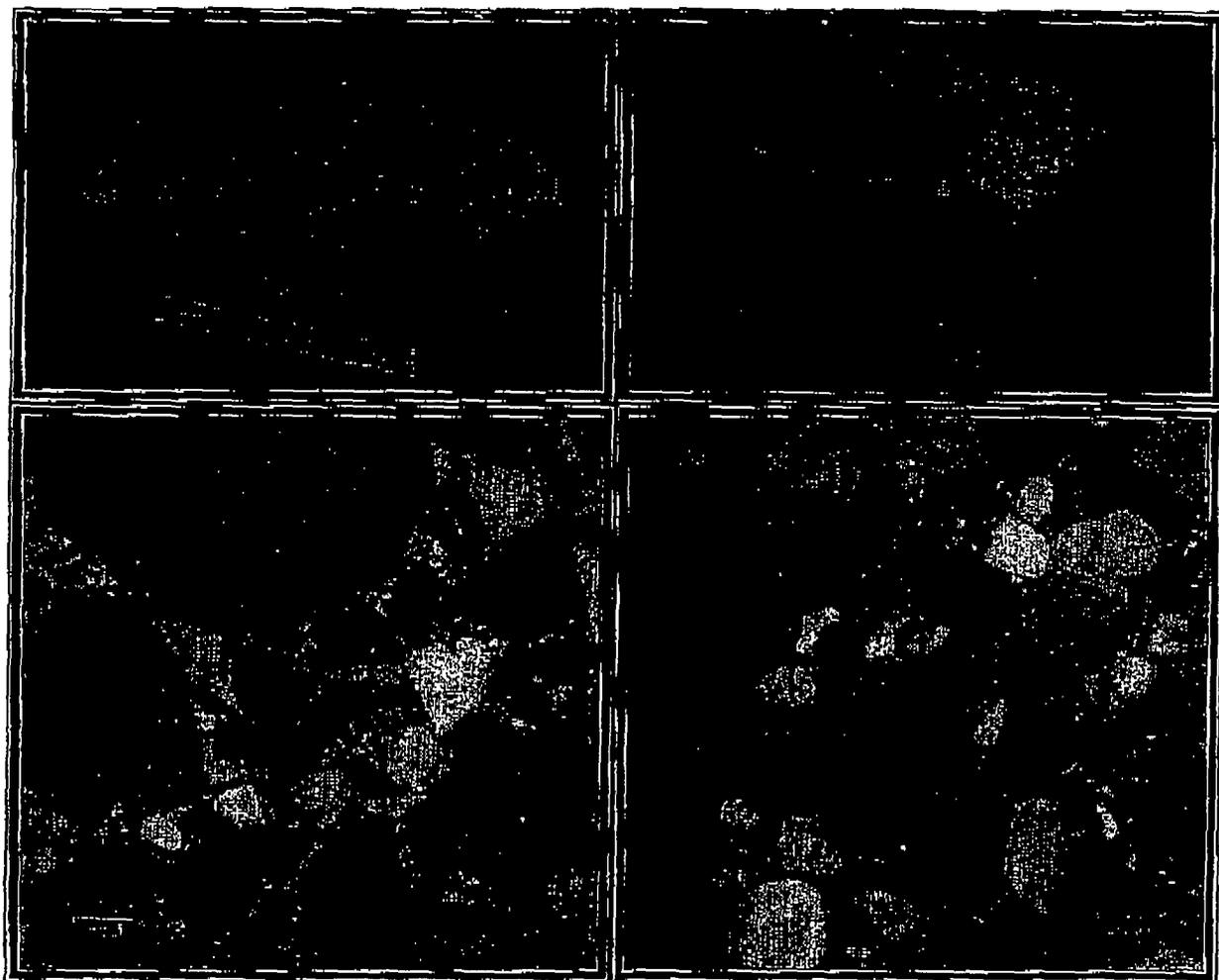


Figure F1. Photographs of sample. (a) As-received condition. (b) Polished cross section cut through rock; scale at bottom in millimeters. (c) Plane-polarized transmitted light photomicrograph of thin section. (d) Cross-polarized transmitted light photomicrograph of thin section.

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ANALYSIS OF ROCK SAMPLES FROM VALLEY CITY AGGREGATE  
DEPOSITS NEAR MOAB, UTAH



**Prepared for:** Mr. Mike Fortner  
Geotechnical Engineering Group, Inc.  
Grand Junction, Colorado

**Prepared by:** David Rothstein, Ph.D., R.G.  
**Report No.:** DRP06.310

1 SEPTEMBER 2006

## 1.0 INTRODUCTION

Pursuant to the request of Mr. Mike Fortner of the Geotechnical Engineering Group, Inc. (GEG) located in Grand Junction, Colorado the purpose of the investigation is to assess the engineering properties of rock samples proposed for use as rip rap. DRP Consulting, Inc. (DRP) received two (2) rock samples from (GEG) on 11 July 2006 and was authorized and paid to proceed with the analysis of the samples on 31 July 2006. The samples are listed below in Table 1. GEG indicated that the primary interest in conducting the analyses was to assess the occurrence of clay minerals and the amount of weathering in the materials represented by the samples.

Table 1. List of Samples

GEG Sample ID	DRP No.
Stoller Orthoquartzite	10YD2447
Orthoquartzite Conglomerate	10YD2448

## 2.0 SCOPE OF WORK

The investigation involved microscopical analysis of the samples. This report summarizes the main findings of this investigation. Appendices A-F give specific information on each sample.

## 3.0 PROCEDURES

*Petrographic Analysis* The rocks were photographed in their as-received condition, described, and cut into slabs with a water-cooled saw. The slabs were lapped and polished using diamond-embedded wheels and an aqueous lubricant/coolant. Thin sections were prepared at Spectrum Petrographics in Vancouver Washington. The samples were examined with a stereomicroscope capable of a 3-180x magnification range and a petrographic microscope capable of 50-500x magnification range. The rocks were examined to obtain a geologic description, estimate of the modal mineralogy, to assess the presence of clay minerals and evaluate the weathering of the rock. The modal mineralogy was estimated visually on the basis of thin section examination. The weathering was assessed using the classification scheme of the International Society of Rock Mechanics.

**4.0 FINDINGS**

The following summarizes the findings from this investigation regarding the materials represented by the samples:

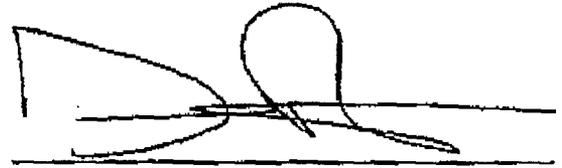
1. The rocks are hard and competent.
2. The rocks are fresh.
3. There is no significant clay mineralization in any of the materials represented by the samples.

Table 2 provides a brief summary of the results:

Table 2. Summary of Results				
GEG No.	DRP No.	Rock Name	Clay	Weathering
Stoller Orthoquartzite	10YD2447	Chert-cemented quartzite	None	Fresh
Orthoquartzite	10YD2448	Chert-cemented quartz	Trace	Slight
Conglomerate		pebble conglomerate		

This concludes work performed on this project to date.

DRAFT



David Rothstein, Ph.D., P.G.

APPENDIX A: Valley City Aggregate

Report No. DRP06.310

Sample ID: Stoller Orthoquartzite (10YD2447)

Date: 1 September 2006

1. RECEIVED CONDITION	
ROCK NAME	Chert-cemented quartzite
SHAPE & SURFACES	Block-like cobble, rough surfaces. Two surfaces present significant dark brown to black staining.
GENERAL COMMENT	Sample is hard and competent and presents several hairline cracks.

2. PETROGRAPHIC OVERVIEW	
MINERALOGY/MODE (EXCLUSIVE OF POROSITY)	Monocrystalline quartz: 55% Siliceous volcanic rock: 10% Silicified limestone: 6% Polycrystalline quartz: 4% Feldspar: 2% Hematite: 1% Chalcedonic Cement: 22%  Clay minerals: none observed
TEXTURE	Mostly fine-grained quartzite with some medium-grained pebbles. Monocrystalline quartz grains are mostly sub-round with some sub-angular fragments and are relatively fine-grained. Coarse particles consist of tabular to sub-round fragments of siliceous volcanic rock and silicified limestone.
WEATHERING	Rock is slightly weathered in ISRM classification, based on presence of staining on two outer surfaces of the rock. The staining does not persist into the fabric of the rock.

3. COMMENTS	
The porosity and induration of this rock is probably fairly consistent but the extent of microcracking may vary greatly. Various engineering tests will be needed to determine the suitability of the material for a given application. This rock is rich in chalcedonic chert, which tends to be highly reactive for alkali-silica reaction, so this rock is not suitable for use as an aggregate in concrete unless significant measures are taken to mitigate its potential reactivity.	

FIGURES

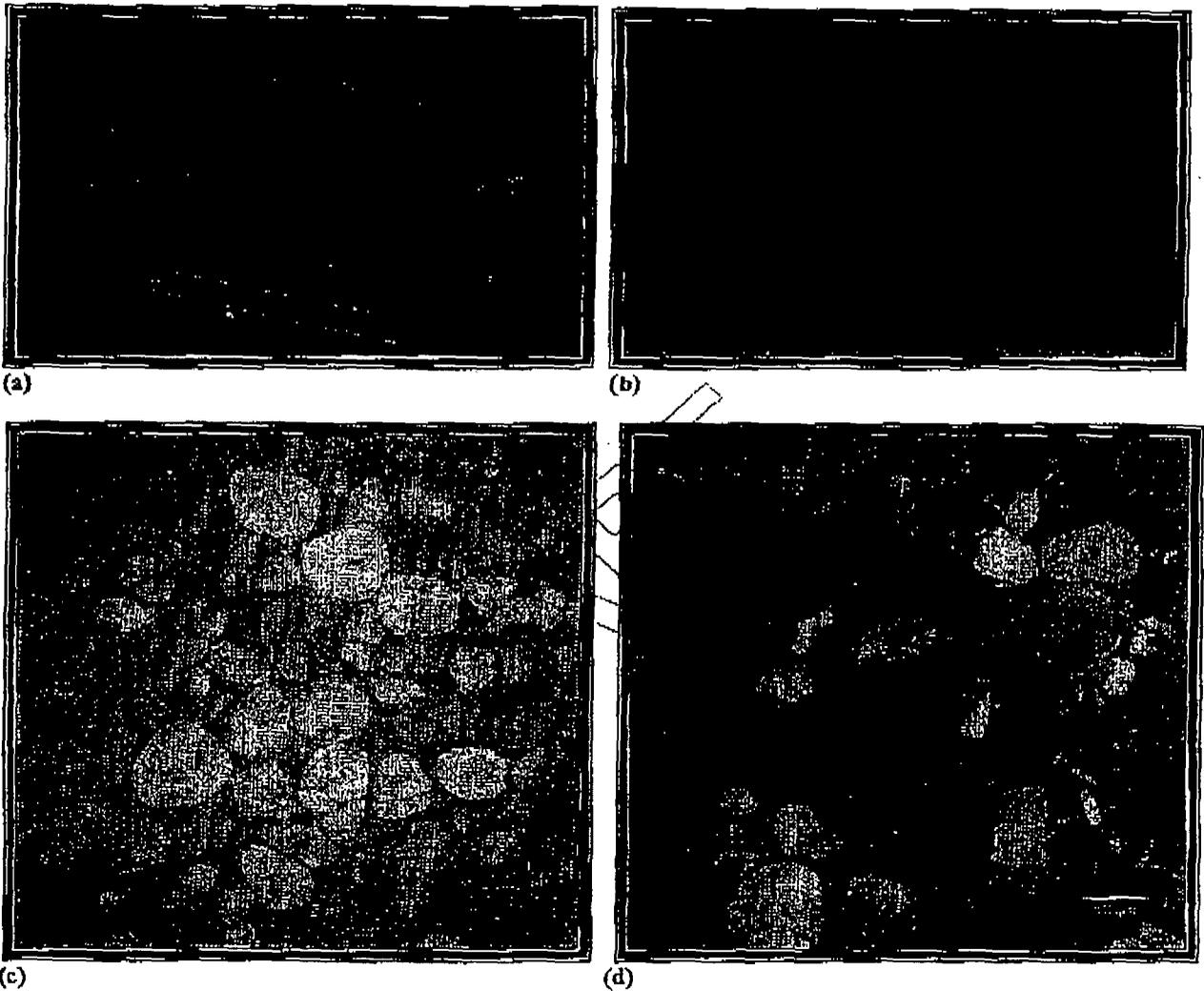


Figure A1. Photographs of sample. (a) As-received condition. (b) Polished cross section cut through rock; scale at bottom in millimeters. (c) Plane-polarized transmitted light photomicrograph of thin section. (d) Cross-polarized transmitted light photomicrograph of thin section.

APPENDIX B: Valley City Aggregate  
 Sample ID: Orthoquartzite Conglomerate (10YD2448)

Report No. DRP06.310  
 Date: 1 September 2006

1. RECEIVED CONDITION	
ROCK NAME	Chert-cemented quartz pebble conglomerate
SHAPE & SURFACES	Block-like cobble, rough surfaces. Clay deposits on some faces.
GENERAL COMMENT	Rock is hard and intact and presents several hairline cracks.

2. PETROGRAPHIC OVERVIEW	
MINERALOGY/MODE (EXCLUSIVE OF POROSITY)	Monocrystalline quartz: 40% Siliceous volcanic rock: 25% Silicified limestone: 10% Hematite: 1% Chalcedonic cement: 24%  Clay minerals: none observed
TEXTURE	Medium- to coarse-grained, pebbly conglomerate consisting of particles of monocrystalline quartz, siliceous volcanic rocks, granitic igneous rocks, and silicified limestone. Rocks are round to subangular; the fabric is massive and shows weak bedding. Cracks run through rock in two orthogonal directions with minor clay mineralization along some segments of cracks.
WEATHERING	Rock is slightly weathered in ISRM classification.

**3. COMMENTS**

The porosity and induration of this rock is probably fairly consistent but the extent of microcracking may vary greatly. Various engineering tests will be needed to determine the suitability of the material for a given application. This rock is rich in chalcedonic chert, which tends to be highly reactive for alkali-silica reaction, so this rock is not suitable for use as an aggregate in concrete unless significant measures are taken to mitigate its potential reactivity.

APPENDIX B: Valley City Aggregate  
Sample ID: Orthoquartzite Conglomerate (10YD2448)

Report No. DRP06.310  
Date: 7 September 2006

## FIGURES

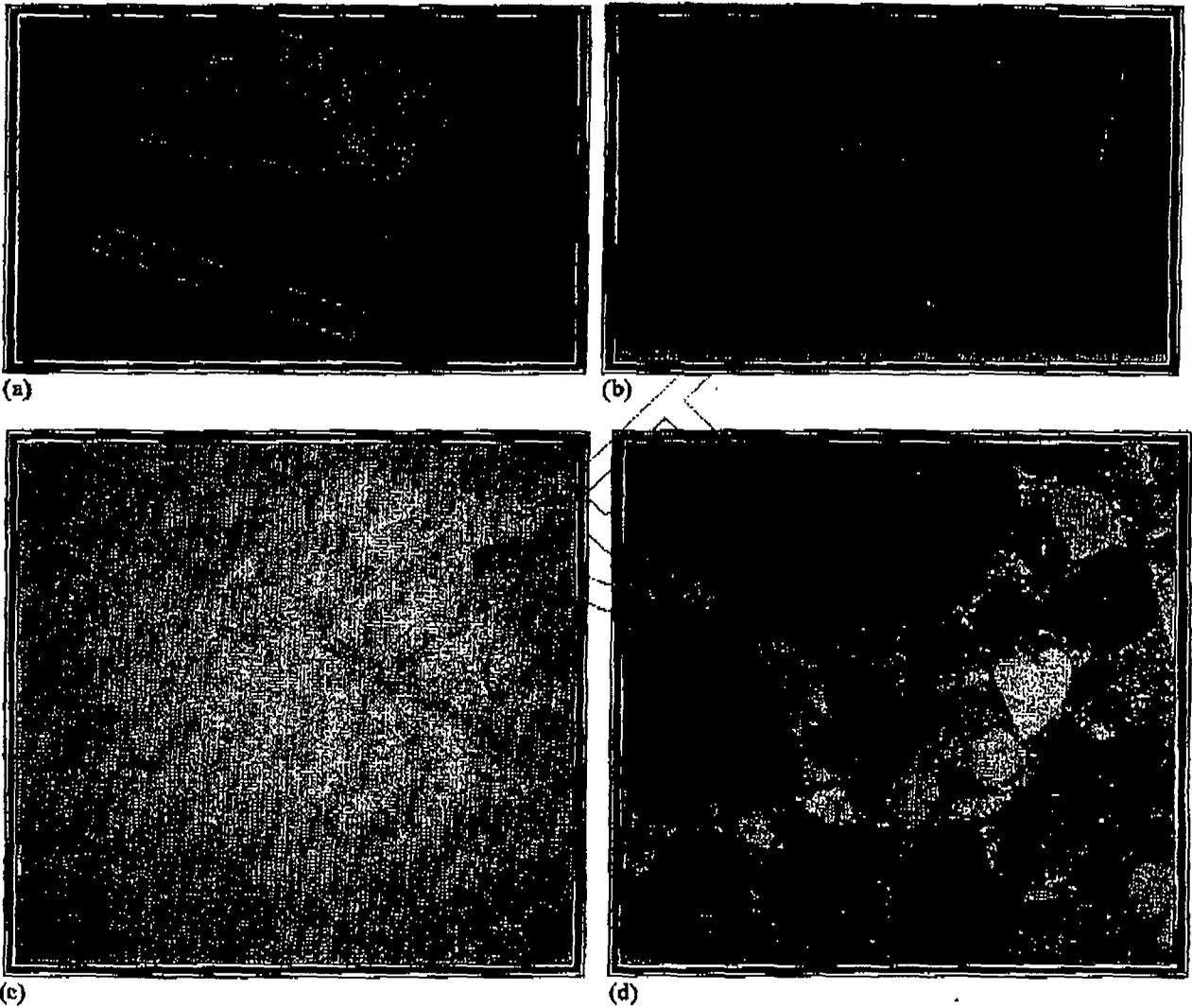


Figure B1. Photographs of sample. (a) As-received condition. (b) Polished cross section cut through rock; scale at bottom in millimeters. (c) Plane-polarized transmitted light photomicrograph of thin section. (d) Cross-polarized transmitted light photomicrograph of thin section.