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June 20, 2012

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Attention: Document Control Desk
Director, Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

References:

1. Docket No. 40-3392; License SUB-526
2. Letter from Larry Smith, Plant Manager Honeywell, to the NRC, Surface Impoundment Decommissioning Plan, dated December 2, 2010
3. Letter from Larry Smith, Plant Manager Honeywell, to the NRC, Supplemental Information for the Surface Impoundment Decommissioning Plan Application, dated February 25, 2011
4. Letter from NRC to Larry Smith, Plant Manager Honeywell, Completion of Acceptance Review for Honeywell Metropolis Works' Surface Impoundment Decommissioning Plan (TACL32759), dated March 17, 2011
5. Site visit conducted Wednesday, October 5, 2011, at Honeywell Metropolis Works' facility
6. Letter from NRC to Larry Smith, Plant Manager Honeywell, Request for Additional Information Regarding the Surface Impoundment Decommissioning Plan for Honeywell Metropolis Works (TACL32759), dated November 4, 2011
7. Letter from Larry Smith, Plant Manager Honeywell, to the NRC, Request for 30-day extension to respond to RAI's dated December 29, 2011
8. Letter from NRC to Larry Smith, Plant Manager Honeywell, NRC approval of request for 30-day extension of RAI's and continuance of overall submittal review dated January 17, 2012
9. Letter from NRC to Larry Smith, Plant Manager Honeywell, NRC Request for Additional Information (RAI) Supplemental Summary of 2011 Pozzolan Testing Information dated March 21, 2012 (TACL32759)
10. Letter from NRC to Larry Smith, Plant Manager Honeywell, NRC Request for Additional Information (RAI) Honeywell's Riprap Durability Evaluation Report of Cypress Quarry (Rip Rap Report), May 2012, dated June 8, 2012

Subject: Response to Request of Additional Information (RAI) Concerning the Honeywell's Riprap Durability Evaluation Report of Cypress Quarry (Rip Rap Report), May 2012 Information for Surface Impoundment Decommissioning Plan (TACL32759)

Honeywell Metropolis Works hereby submits the following response to the request for additional information (Ref. 10) issued by the NRC on June 8, 2012, and received by Honeywell Metropolis Works facility (MTW) on June 14, 2012.

NMSS01

If you or your staff have any questions, require additional information, or wish to discuss this, please contact Bob Stokes, Regulatory Affairs and Radiation Protection Manager, at (618) 524-6341.

Sincerely,

Larry A. Smith
Plant Manager

cc: John Sulima, NMSS Project Manager
Mail Stop EBB 2-C40M
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

REQUESTS FOR ADDITIONAL INFORMATION REGARDING HONEYWELL'S RIPRAP DURABILITY EVALUATION: CYPRESS QUARRY (RIPRAP REPORT), May 2012

The Riprap Report is a supplement to the "License Amendment Request Report, U.S. NRC License Number SUB-526, Closure of Surface Impoundment Retention Ponds B, C, D, and E, Honeywell Metropolis Works" (LARR), which serves as the Decommissioning Plan for Honeywell's amendment request.

The information requested in the following requests for additional information (RAIs) on the Riprap Report is needed for the U.S. Nuclear Regulatory Commission's (NRC's) staff to determine compliance with the dose requirement for unrestricted use in 10 CFR 20 Subpart E, and to assess the applicant's design of engineered barriers for erosion control with respect to the guidance specified in NUREG-1757 and in NUREG-1623.

Variability of Rock Units Important to Producing the Required Rock Size

RAI 1

On page 1, the Riprap Report states that a 12-inch D_{50} rock is needed. Table 5-4 in Volume 2 of the LARR indicates the need for riprap with a D_{50} range from 11 to 18 inches or more—depending on the response to RAI 3 for Volume 2 of the LARR on the D_{50} analysis. On page 3, fifteen significant bedding planes are noted; but the thickness of rock units between these bedding planes was not given, and the variability of the units between the major bedding planes was not described. The presence of bedding planes can limit the size of the riprap material, and these features could be planes of weakness, which can cause riprap to weaken and reduce the size of the rock material. Provide the general thickness and describe the homogeneity of the units between the major bedding planes. If smaller bedding planes exist within these units, provide the general thickness of units between the smaller bedding planes. Based on this information, evaluate whether riprap can be produced with a D_{50} of up to 18 inches that is free of bedding planes or stylolites that could cause future degradation of the riprap and reduction of the riprap size. Also discuss if certain units in the upper and lower benches would be preferable and therefore targeted for production of the larger-sized riprap.

RESPONSE to RAI 1

There are three primary locations requiring riprap: side slope, interior ditches, and perimeter ditches. The riprap D_{50} values listed in Table 5-4 in Volume 2 of the LARR for the interior and perimeter ditches (11 inches and 18 inches, respectively) correspond to the maximum expected flowrate in any ditch segment. The riprap gradations will be optimized for specific ditch segments prior to construction, which may result in smaller riprap sizes in some locations.

The bedding planes encountered at the site generally are spaced at intervals of 1 to 2 feet in the upper bench and 1 to 4 feet in the middle and lower benches and should not impact the size or durability of the riprap produced. Stylolites are present in the lower bench but do not appear to affect the durability of the rock, based on site observations where stylolites remained intact after a bench shot. The same observation was made in stockpiles of riprap in other locations within the quarry.

The upper and lower benches are both capable of producing the diameters of rock required for the project. There appear to be no limitations associated with producing the size of the rock required for the project from either bench.

RAI 2

The presence of stylolites and clay seams can limit rock size since these features can be more

susceptible to weathering. Stylolites are shown in the slabbed samples of UB-1 and UB-2 shown in Photos 10 and 11 of Appendix B of the Riprap Report. The petrographic analysis of the UB-1 sample also noted numerous clay seams. Describe these features in the upper bench, if they are representative of the upper bench, and if they could limit the size of the rock produced.

RESPONSE TO RAI 2

Clay seams were not noted in the petrographic reports, but the presence of clay-sized minerals consisting of mostly quartz and calcite was noted. The dark seams observed in the cut samples do not appear to be planes of weakness based on rock observations made at the quarry and the petrographic analyses, and, therefore, should not affect the size of riprap produced.

Representativeness of Samples

RAI 3

The discussion on page 2 explained that 7 representative samples for durability tests were selected from the 15 samples collected from the 3 benches in the quarry, but no explanation was given for how the 7 samples for durability tests were selected and if they are representative. Provide a discussion of how the 7 samples were selected. Were the 7 samples the same types of limestone as the 15 samples (as classified by Dunham for example, mudstone or packstone)?

RESPONSE TO RAI 3

Five representative samples were collected from each of the upper, middle, and lower benches. The samples were grouped based on visual classification of the rock in the field taking into account the color and matrix of the rock, specifically the presence of allochems and packing of the framework grains (mudstone, wackestone, packstone, grainstone) in accordance with the Dunham approach as shown in Figure 1 (Klein, 1993). For the upper and lower benches, at least one representative sample was tested from each defined group. Three samples were tested from the middle bench, focusing on apparent variability among the grainstone samples. See Table 1 under response to RAI 5.

Additional lower bench samples were tested for absorption, as described in the response to RAIs 5 and 10 and included in Attachment 1.

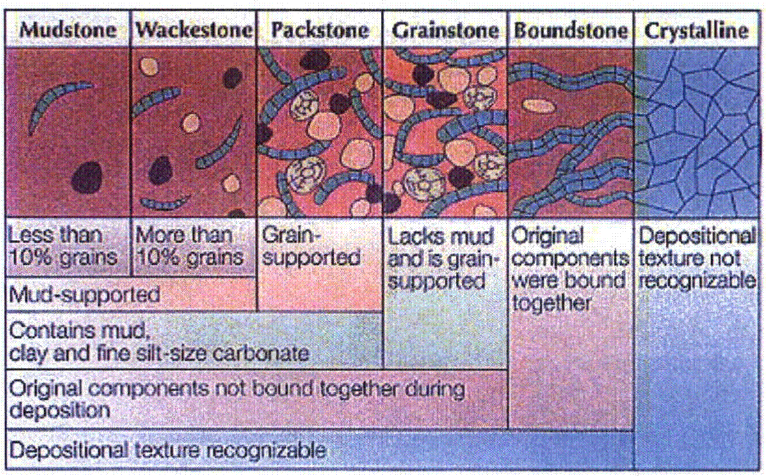

Figure 1. Dunham classification system for carbonate sedimentary rocks (Klein, 1993)

RAI 4

On page 5, it was noted that an U.S. Army Corps of Engineers' (Corps) report identified zones of argillaceous limestone in the quarry and that samples were tested. No further information from this

report was provided. Understanding the distribution of argillaceous material is important since its presence can increase the susceptibility of the rock to weathering and can cause a reduction in the riprap size. Provide a summary from the Corp's report regarding the argillaceous limestone, including location within the quarry sequence or benches, if known, and any laboratory test results for this zone. Furthermore, did Honeywell sample this zone? If so, what are the test results and scores? Can these zones be easily identified and avoided?

RESPONSE TO RAI 4

The exact location of the argillaceous limestone is not noted in the USACE report *Petrographic Examination US Army Corp of Engineers Shawnee Stone, Cypress Quarry Erosion Control Stone Samples UL-FG (Upper Level–Fine Grained)*. The Corps report indicates that the samples were collected from the "upper level" – which corresponds to the upper part of the middle bench in the Honeywell report, as represented by sample MB-1. The middle bench will not be used as a source of riprap for this project. Nonetheless, a copy of the requested Corps report is included as Attachment 2.

Seven samples were collected by the Corps and described as very light gray to light gray, finely crystalline, argillaceous dolomitic limestone with dark gray to black stylolites and medium light gray bedding planes. Some dark gray chert nodules are present in all samples with some sparry dolomite, scattered pyrite, and microfossils. Several faces on the sample appear to have been created from the breakage of stylolites. The samples had a tendency to part along preexisting fractures and stylolites which could pose problems producing suitable riprap sizes of the argillaceous limestone. The collected samples possessed a uniform lithology and composition and were moderately soft, porous, rough, and durable to nondurable.

The result of the petrographic examination indicated that the fine-grained riprap in the "Upper Level" (i.e., upper part of the middle bench in the Honeywell report) is of poor quality for use as erosion control because of its softness and closely spaced open fractures. This is consistent with the middle bench rock observations described in the Honeywell report. Sample MB-1 was not tested, since historical testing of this zone identified the rock as an unsuitable source of riprap.

RAI 5

On page 6, it is noted that samples were collected from each quarry bench; but it is not clear if these samples are for each limestone type/lithofacies (e.g., Dunham's classification used in the petrographic analyses in Appendix B) identified in each bench. Are the samples representative of each limestone type expected to be used? On page 7, it was noted that the 7 samples selected for durability testing were selected on the basis of variation in each bench; but it is not clear what variation was considered and if these samples represent each limestone type expected to be used. Provide a clarification that addresses these questions.

RESPONSE TO RAI 5

See response to RAI-3, and Table 1 below summarizing the rock samples collected from the upper, middle, and lower benches (UB, MB, LB, and historic quarry face (OLD), respectively).

Table 1. Summary of Rock Samples Collected: Cypress Quarry December 2011

Sample ID	Color	Texture / Matrix	Description	Dunham Group
UB-1[a,c,d]	Brownish gray to dark gray	< 10% grains	Micritic limestone	Mudstone
UB-2	Brownish gray to dark gray	< 10% grains	Micritic limestone	Mudstone
UB-3	Brownish gray to dark gray	< 10% grains	Micritic limestone	Mudstone
UB-4[a]	Brownish gray to dark gray	< 10% grains	Micritic limestone	Mudstone
UB-5	Brownish gray to dark gray	< 10% grains	Micritic limestone	Mudstone
MB-1	Gray to dark gray	Grain supported	Fossiliferous limestone	Packstone
MB-2[a]	White to light gray	Lacks mud	Oolitic limestone	Grainstone
MB-3[a,c]	Light gray to gray	Lacks mud	Fossiliferous limestone	Grainstone
MB-4[a,c]	White to light gray	Lacks mud	Oolitic limestone	Grainstone
MB-5[c]	Light gray to gray	Grain supported	Fossiliferous limestone	Packstone
LB-1[b]	Light gray to gray	Grain supported	Fossiliferous limestone	Packstone
LB-2[b]	Gray to dark gray	Grain supported	Fossiliferous limestone	Packstone
LB-3[a,c]	Gray to dark gray	Lacks mud	Fossiliferous limestone	Grainstone
LB-4[b]	Gray to dark gray	Lacks mud	Fossiliferous limestone	Grainstone
LB-5[a,c]	Light gray to gray	Grain supported	Fossiliferous limestone	Packstone
OLD-1	Light gray to gray	Grain supported	Fossiliferous limestone	Packstone
OLD-2	Light gray to gray	Grain supported	Fossiliferous limestone	Packstone
OLD-3	Light gray to gray	Grain supported	Fossiliferous limestone	Packstone

[a] Samples tested in the laboratory for Specific Gravity/ Absorption (ASTM C127), Sodium Sulfate Soundness (ASTM C88), L.A. Abrasion (ASTM C535), and Rebound Hardness (ASTM D5873).
[b] Samples tested in the laboratory for Specific Gravity/ Absorption only (ASTM C127).
[c] Petrographic analysis performed (ASTM C295).
[d] X-Ray Diffraction performed.

Quality Assurance Procedures for Rock Production

RAI 6

Text on pages 2 and 7 of the Riprap Report correctly indicates the need for quality assurance procedures to avoid production of unacceptable rock or rock with adverse features. Provide a commitment to prepare these procedures and submit them to NRC for approval before production of the rock. Production procedures should also include the potential for identifying and removing concentrations of stylolites.

RESPONSE TO RAI 6

Honeywell commits to prepare quality assurance procedures that specify the steps necessary to avoid the production of unacceptable rock or rock with adverse features prior to construction. The procedures will specify steps to identify and remove concentrations of stylolites or sandstone interbedding, if encountered. The procedures will be submitted to NRC for approval before production of the rock.

RAI 7

The discussion on page 4 indicates that about 10 feet (ft) of the Aux Vases Formation (Aux Vases) is exposed at the quarry and overlies the St. Genevieve Formation (St. Genevieve) that is proposed for use as riprap for the Honeywell project. The description indicates that the contact between these two formations is gradational and that the Aux Vases Formation consists mainly of sandstone, shale, and limestone. The description of the Geologic Setting also indicates that the upper St. Genevieve can have interbeds of sandstone and shale similar to those in the Aux Vases. The presence of such interbeds can affect the weathering susceptibility, size and durability of the rock. Therefore, discuss if these interbeds in the St. Genevieve were observed at the quarry and if these potentially unacceptable rock types—either in the St. Genevieve and the overlying Aux Vase—are easily identifiable. On page 11, the procedure discussion only mentions that the overburden and Aux Vases sandstone will be completely stripped or removed before mining the upper bench. While this is appropriate, the procedures to be developed will need to also describe how to identify unacceptable rock from either the Aux Vases or upper units of the St. Genevieve, how they would be removed, and how produced rock will be checked to ensure that unacceptable rock has been avoided.

RESPONSE TO RAI 7

The regional geologic description of the Aux Vases and St. Genevieve is as noted in the text. The local geologic description of the St. Genevieve differs slightly from the regional description in that there was no observed interbedding of the sandstone in the heading or sidewalls of the quarry and therefore is not of concern at this time. Steps to identify and remove sandstone interbedding (from any formation), concentrations of stylolites, and stripping of the Aux Vases sandstone will be addressed in the quality assurance procedures to be prepared prior to construction (see response to RAI-6).

Natural Analogues

RAI 8

Pages 10 and 11 discuss natural analogues that show long-term durability of similar rock at another location. The discussion notes that the St. Genevieve is similar in "composition" to the Kelley's Island limestone in Ohio, and had a similar depositional history. It is not clear what "composition" means. Does composition include specific limestone types classified by Dunham for example (e.g., are they both mudstones?). This information is needed to further verify the similarity of the two rock formations and therefore the credibility of the analogue comparison.

RESPONSE TO RAI 8

The exposed Columbus Limestone at Kelley's Island in Ohio consists of a range of dolomitic limestone comprised of mudstones, packstone, and grainstone (Dunham groups) similar to what was encountered in the St. Genevieve Formation at the Cypress Quarry (Snow, 1991).

RAI 9

The discussion of the Kelley's Island analogue on pages 10 and 11 describes large glacial grooves (15 ft deep and 35 ft wide) and striations. Elaborate on the description of striations and polished surfaces at Kelley's Island based on the literature, including extent of striations, depth of these scratches and extent of glacially polished surfaces that have been preserved. Preservation of such fine markings over a 10,000-year period is more significant than the very large, deep grooves also present. This striation information is needed to better understand the preservation of very fine markings on the limestone at the Kelley's Island location that qualitatively demonstrates the long-term durability of similar limestones from the St. Genevieve Formation.

RESPONSE TO RAI 9

The glacially formed grooves, striations, and polished rock surfaces, some of the most spectacular exhibits of glacial grooves in the world, were first documented as early as 1833. The grooves at Kelley's Island that have not been disturbed by economic activity range up to 65 feet wide, 20 feet deep, and nearly 1,300 feet long (Goldthwait, 1979). Durability of the rock mass is demonstrated by the presence of the polished limestone surfaces bearing shallow scratches and striations. Although there is some dispute regarding the formation of the glacial grooves, there is little debate that the abrasion of icebound rock formed the polished striated surfaces exposed today that were formed more than 15,000 years ago and subsequently covered with glacial till over a period of about 4,500 years, preserving the features. The glacial features that have been observed over the last 180 years have not shown significant signs of weathering other than chipping and pitting demonstrating the long term durability of the rock mass and its ability to resist weathering (Goldthwait, 1979).

Oversizing Considerations

RAI 10

On page 9, the lower rock durability score of 75 for sample LB-5 was discussed and that oversizing the rock would require an increase of about 5 percent in the D_{50}. Provide a discussion of the potential reason for the low score that was strongly influenced by a very low absorption test result. Discuss if simple oversizing will mitigate the cause of the lower score. Also, discuss if this sample is considered representative of the lower bench. Consider if the test result could represent a feature in the lower bench that should be avoided. This information is needed to assess whether oversizing can compensate for a lower rock durability score. In situations where rock contains such features as high porosity zones and shale interbeds, oversizing might not ensure that adequate rock size will be maintained over the long term.

RESPONSE TO RAI 10

Additional absorption tests were performed on all lower bench samples (including retesting of samples LB-3 and LB-5) to evaluate the variation in this parameter. Test results are summarized in Table 2, and included in Attachment 1. Summary statistics of the lower bench absorption samples were calculated as shown in Table 3. Results show sample variance of 0.087 percent for all samples, suggesting that the mean value of 0.716 percent is a representative absorption value for the lower bench. This falls within the "fair" range of the scoring table. Using the highest tested absorption value of 1.147 percent, with an associated absorption quality score of 4.71, the overall weighted quality score for the sample (all other parameters being equal) would be 71 percent, with an associated oversize requirement of less than 10 percent.

The significance of the absorption test is that excessive absorption of water into rock may affect its durability under freezing conditions and salt crystallization conditions. Based on the observations in the petrographic reports, each of the upper and lower bench samples have relatively low porosity (less than one percent). The range in the absorption test results appears to represent the natural range in porosity of the lower bench rock, with no clear anomalies associated with the highest absorption test values.

Based on the above, we propose a 10 percent oversizing of D_{50} for the lower bench riprap.

Table 2. Laboratory Testing Absorption Values: Lower Bench Samples

Sample ID	Absorption Value (%)	Score (NUREG 1623)
LB-1 [a]	0.594	7.45
LB-2 [a]	0.462	8.19
LB-3	0.31	8.95
LB-3 [a]	0.665	7.03
LB-4 [a]	0.985	5.09
LB-5	0.85	5.88
LB-5 [a]	1.147	4.71

[a] Supplemental Absorption Testing Results Completed May 2012

Table 3. Summary Statistics: Absorption Values, Lower Bench Samples

Mean	0.716
Standard Error	0.112
Median	0.665
Standard Deviation	0.295
Sample Variance	0.087
Kurtosis	-1.000
Skewness	0.149
Range	0.837
Minimum	0.310
Maximum	1.147
Sum	5.013
Count	7.000
Largest	1.147
Smallest	0.310
Confidence Level (95.0%)	0.273

References

Klein, C., Hurlbut. C., 1993. *Manual of Mineralogy – 21st Edition after James D. Dana*. John Wiley and Sons, Inc. New York. p. 575

Goldthwait, R. P. 1979. Giant Grooves Made By Concentrated Basal Ice Streams. *Journal of Glaciology,* Volume 23 No. 89. pp 297–307.

Hansen, M.C. 1988. Glacial Grooves: "Rock Scoutings of the Great Ice Invasion": revisited. *Ohio Geology Newsletter,* Spring. pp 1–5.

Snow, S. R., V. T. Lowell, and F. R. Rupp. 1991. *A Field Guide: Kelleys Island Glacial Grooves, Subglacial Erosion Features on Marblehead Peninsula, Carbonate Petrology, and Associated Palentology.* Department of Geology, University of Cincinnati, Bloomington, Indiana.

Attachment 1: Additional Absorption Test Results

GSI Geotechnical Services, Inc.
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June 13, 2012

Mr. Robert Martin, P.E.
CH2M Hill
135 South 84th Street, Suite 400
Milwaukee, WI 53214

Subject: Laboratory Test Report
Cypress Quarry Riprap Durability Evaluation
Cypress, Illinois
GSI Project No. 127040

Dear Mr. Martin:

The GSI Engineering, LLC (GSI) laboratory received five soil samples for testing in accordance with ASTM C 127 *Absorption of Coarse Aggregate*. The test results are summarized in the table below.

Sample ID	Sample Size (g)	Sample Gradation		Absorption (%)
		Passing Sieve	Retained on Sieve	
LB-1	3973.6	1"	#4	0.594
LB-2	3985.2	1"	#4	0.462
LB-3	3972.7	1"	#4	0.665
LB-4	3951.4	1"	#4	0.985
LB-5	3913.1	1"	#4	1.147

Please contact our office if you have any questions on the enclosed, or if you would like further information.

Respectfully submitted,
GSI Engineering, LLC

David Edwards

David A. Edwards, P.E.
Principal Engineer / Vice President

John J. Schuller
Laboratory Manager

DAE/JJS/sw

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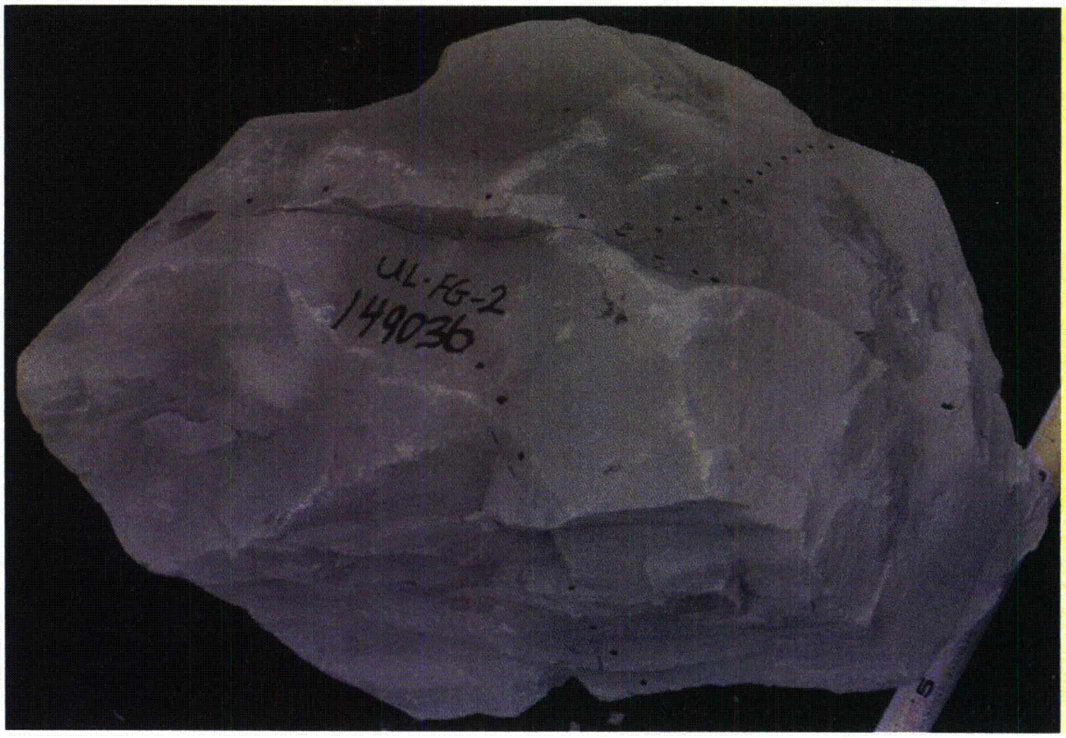
Attachment 2: Corps Petrographic Report

PETROGRAPHIC EXAMINATION
US ARMY CORPS OF ENGINEERS
SHAWNEE STONE, CYPRESS QUARRY
EROSION CONTROL STONE
SAMPLES UL-FG
(UPPER LEVEL – FINE GRAINED)



Prepared by
Robert S. Fousek, P.G.
FMR Inc.
PO Box 2765
Auburn, Alabama 36831

November 29, 2009

NOTE: "Upper Level" as referenced in this Corps report corresponds to the upper portion of the "middle bench" as described in the Honeywell report. This Corps report addresses rock that will not be used as riprap for the Honeywell project.

PETROGRAPHIC EXAMINATION
US ARMY CORPS OF ENGINEERS
SHAWNEE STONE, CYPRESS QUARRY
EROSION CONTROL STONE
SAMPLES UL-FG
(UPPER LEVEL – FINE-GRAINED)

Prepared For

Bowser-Morner, Inc.
BMI No. 149036
Purchase Order No. 21-D11432-JWF

Prepared by
Robert S. Fousek, P.G.
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PO Box 2765
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November 29, 2009

INTRODUCTION

Seven representative samples of Rip Rap from Shawnee Stone, Cyprus Quarry, were shipped by Bowser-Morner, Inc. to FMR Inc. for a petrographic examination to determine its suitability for use as an erosion control stone by the U.S. Army Corps of Engineers. The samples were delivered to FMR Inc. by James Fletcher, Bowser-Morner, Inc. on November 12, 2009. Each individual rip rap sample was marked with a location identifier and an alphabetical designation, i.e., UL-FG-1, UL-FG-2, UL-FG-3, UL-FG-4, UL-FG-5, UL-FG-6, and UL-FG-7 (Figures 1-7). The samples were examined in accordance with ASTM Method C-295, *Standard Guide for Petrographic Examination of Aggregates for Concrete* and paragraphs 4 and 10 ASTM Method D 4992, *Standard Practice for Evaluation of Rock to be Used for Erosion Control.*

METHODOLOGY

The petrographic examination was conducted in accordance with ASTM Method C-295, *Standard Guide for Petrographic Examination of Aggregates for Concrete* and ASTM D 4992, *Standard Practice for Evaluation of Rock to be Used as Erosion Control Stone.* An initial examination of the as received blocks of limestone was conducted both visually and with a stereomicroscope. Sawn and polished blocks along with hand samples of each of the samples were then washed and etched in a solution of 10% hydrochloric acid to facilitate identification of rock types, mineralogy, and textural features. The samples were than washed, dried, and examined visually and with a stereomicroscope. Microphotographs were taken of distinctive features and are shown in the back of this report (Figures 8-13). Descriptions of the samples and the lithology are presented below. The erosion control stone samples are lithologically similar and differ only in size and therefore are described as one lithology.

LITHOLOGY: ARGILLACEOUS DOLOMITIC LIMESTONE

Sample characteristics

The samples varied from 12 to 19 inches long, 10 to 16 inches wide, and 6 to 12 inches thick and weighed 73.0-181.6 pounds. The samples are very light gray to light gray. The samples are moderately soft (Moh's hardness 2.0-2.5), easily scratched with a brass point, and have a blocky to conchoidal fracture.

Medium bedding with bedding defined by slightly darker bands (Figure 9). Finely crystalline, argillaceous and moderately soft, easily scratched with brass pen with Moh's hardness of 2.5 (Figure 9). Numerous thin open fractures, many occurring as closely-spaced (< 1.0 mm) parallel fractures (Figure 10), the fractures presented difficulties during sawing, sample UL-FG-2 was not tested because sample broke into multiple pieces along pre-existing fractures during sawing (Figure 8); sample UL-FG-3 broke into four pieces during sawing; sample UL-FG-4 separated along one edge into 2 pieces during sawing; sample UL-FG-6 separated along pre-existing fractures into three pieces and began to separate along fourth fracture during sawing; and sample UL-FG-7 separated along pre-existing fractures into six pieces during sawing; samples UL-FG-1 and UL-FG-5 were the only two samples that did not break along existing fractures during sawing. Several faces on the samples appear to have been created by breakage along stylolites but no stylolites bounded on each side by argillaceous dolomitic limestone were seen in the samples. The samples obviously have a tendency to part along pre-existing fractures and stylolites and this tendency could present problems maintaining gradation. The samples possess a uniform lithology and composition and are moderately soft, porous, rough, and durable to non-durable.

Composition and Texture

The samples are composed of very light gray to light gray, finely crystalline, argillaceous dolomitic limestone with dark gray to black stylolites and medium light gray bedding planes. Some dark gray chert nodules up to 2 inches across are present in all samples (Figure 11); some sparry dolomite (Figure 12); scattered pyrite, some pyrite oxidizing to iron (Figure 13); some scattered fossil hash and microfossils. The samples are poorly-cemented and moderately soft, easily scratched with a brass point; a few stylolites parallel to subparallel to bedding and lined with black insoluble residue are present. No shale, weathering effects, or other potentially deleterious components were observed. The samples have a weak to moderate reaction to a 10% solution of HCl.

CONCLUSIONS

The results of this petrographic examination indicate the Shawnee Stone, Cyprus Quarry, Upper Level, Fine-Grained rip rap is of poor quality for use as an erosion control stone because of its softness and closely spaced, open fractures.

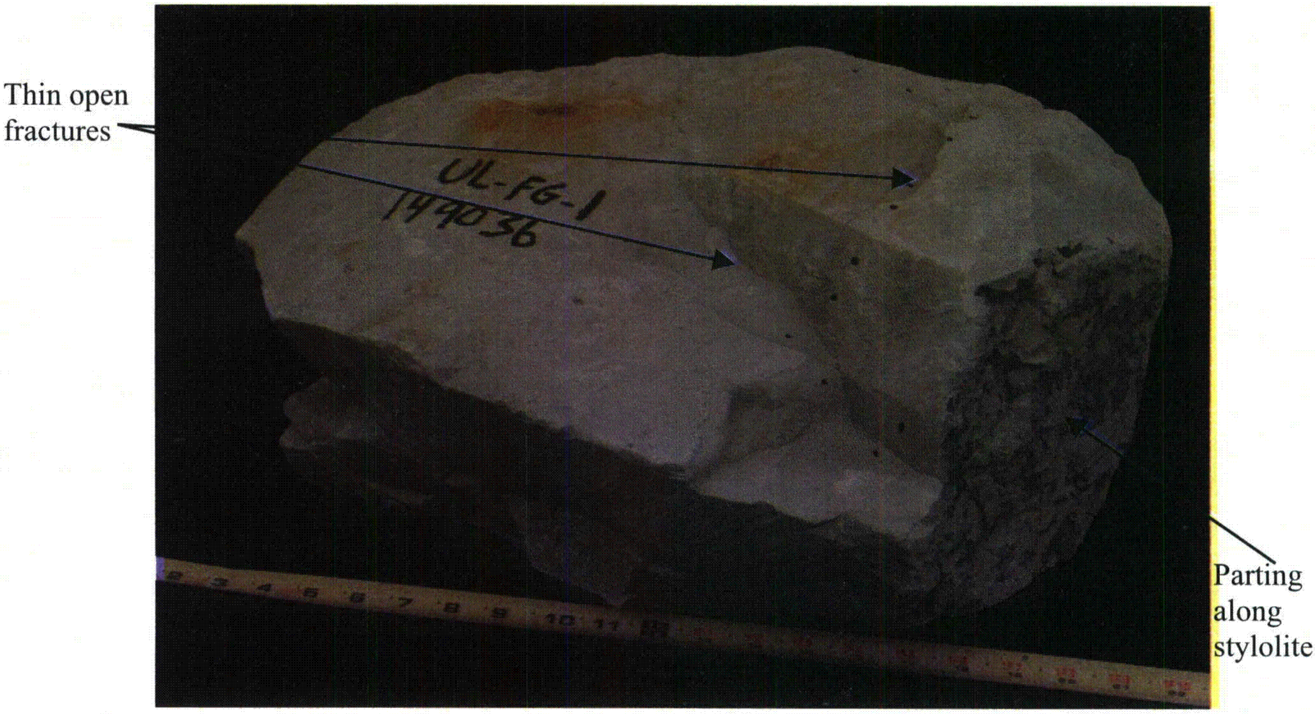

Figure 1. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. UL-FG-1 as received and before washing.

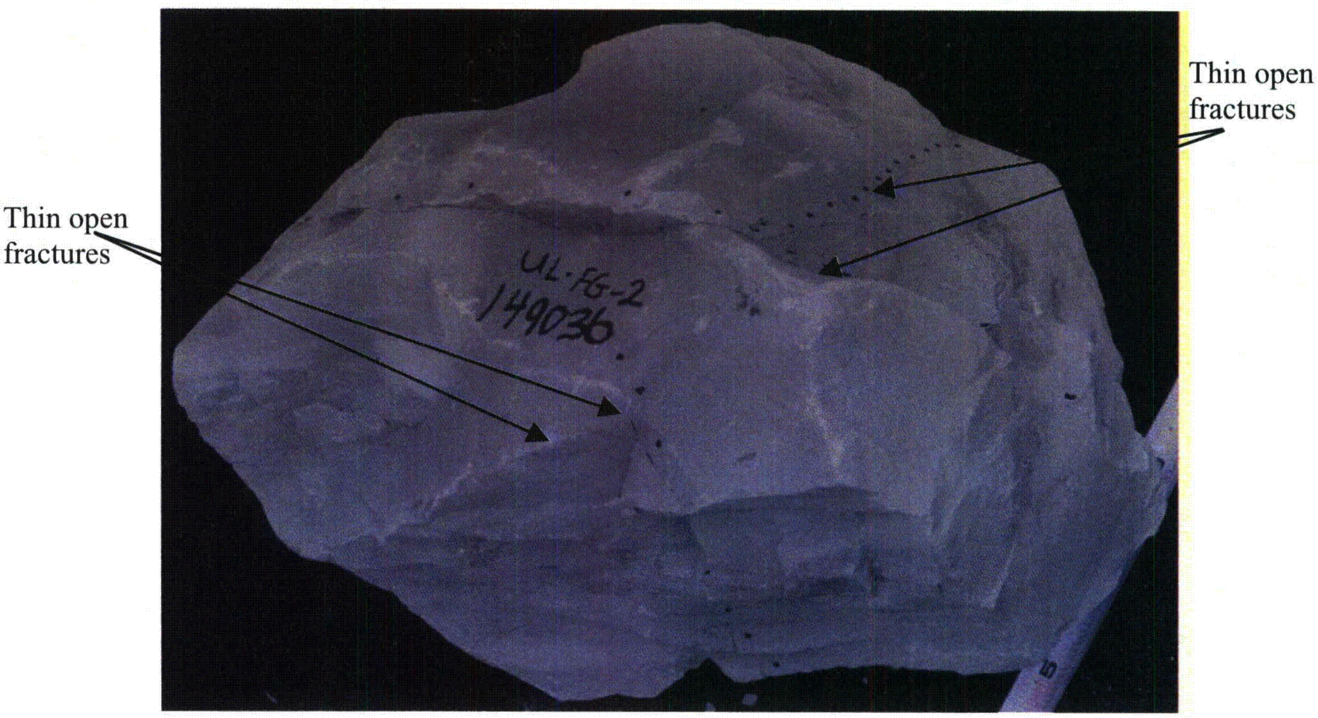

Figure 2. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. UL-FG-2 as received and before washing.

Figure 3. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. UL-FG-3 as received and before washing.

Figure 4. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. UL-FG-4 as received and before washing.

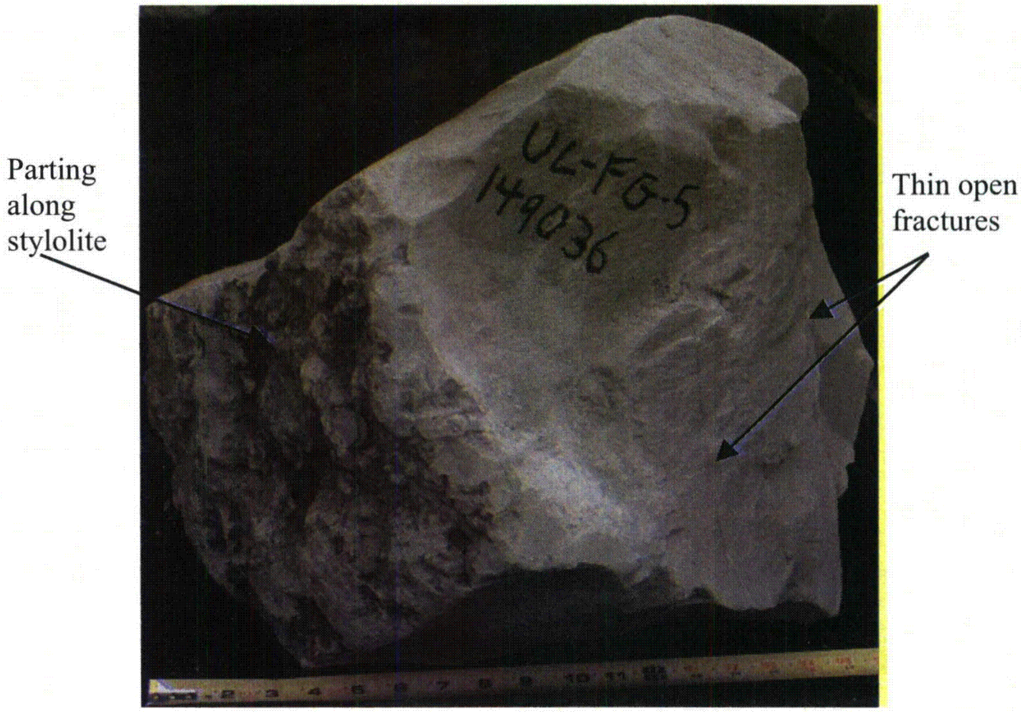

Figure 5. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. UL-FG-5 as received and before washing.

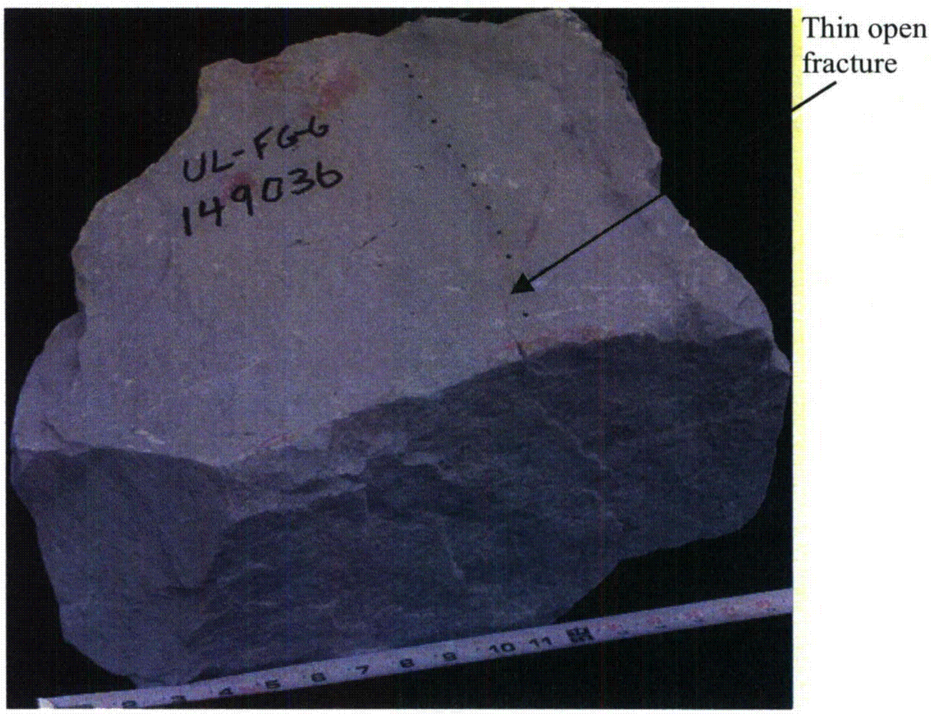

Figure 6. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. UL-FG-6 as received and before washing.

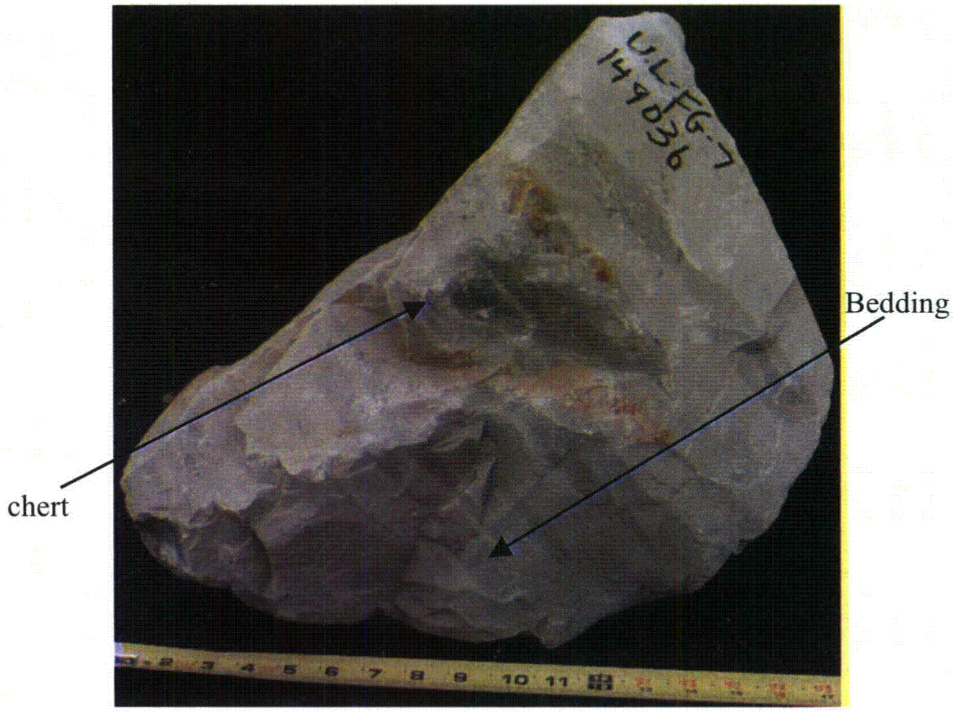

Figure 7. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. UL-FG-7 as received and before washing.

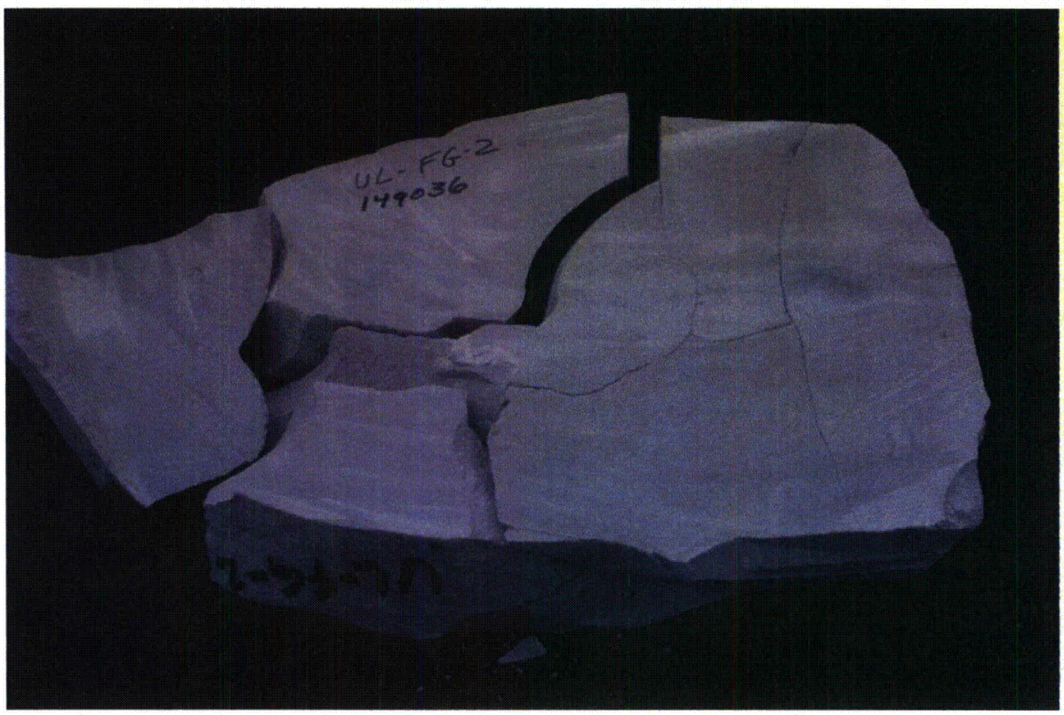

Figure 8. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. UL-FG-2 broke into several pieces during attempt at sawing.

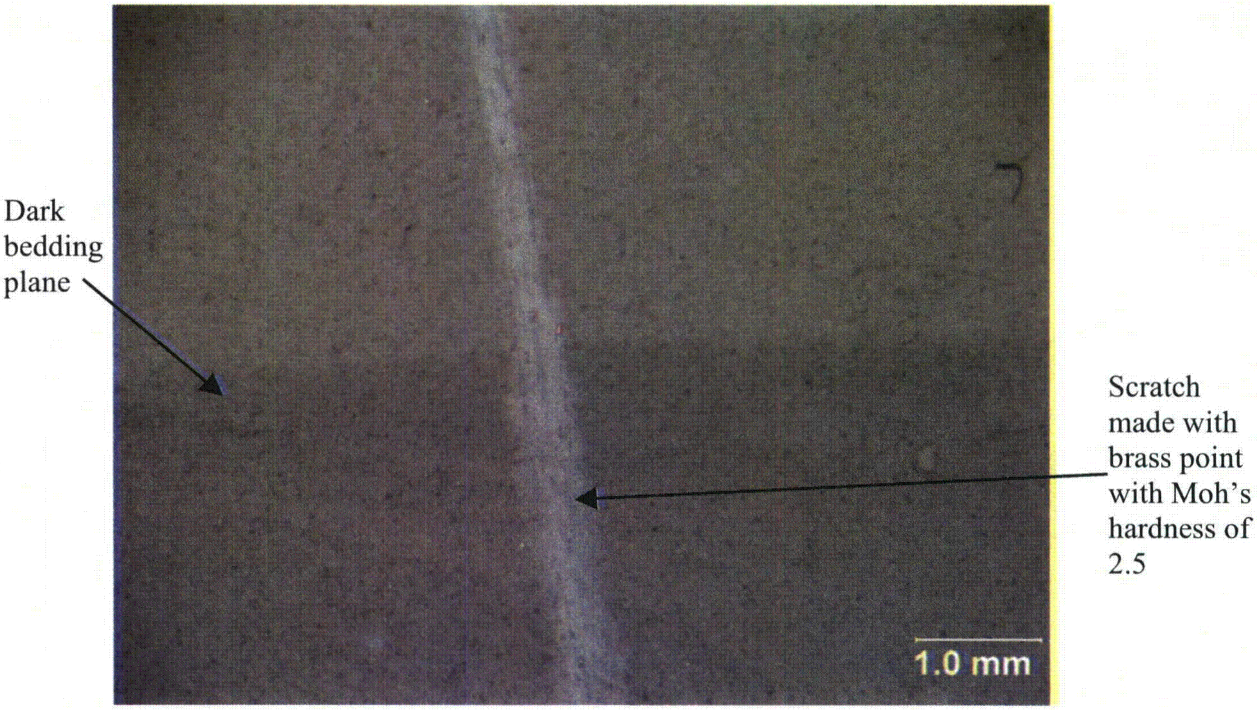

Figure 9. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. Microphotograph of typical argillaceous dolomitic limestone (UL-FG-5). Photographed at 10X magnification.

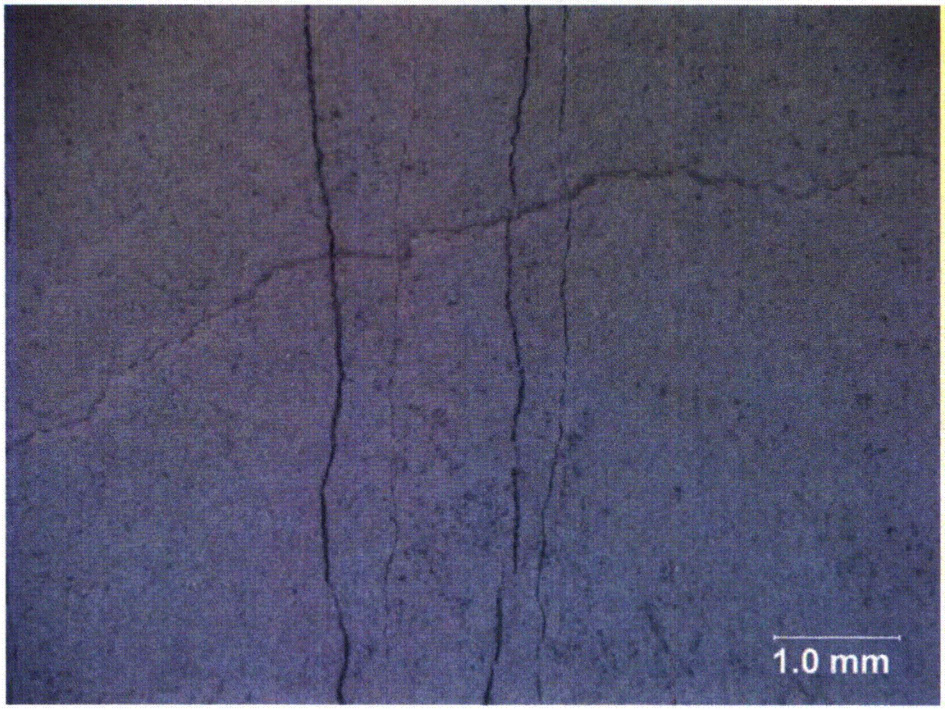

Figure 10. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. Microphotograph of thin closely-spaced, intersecting open fractures (UL-FG-1). Photographed at 10X magnification.

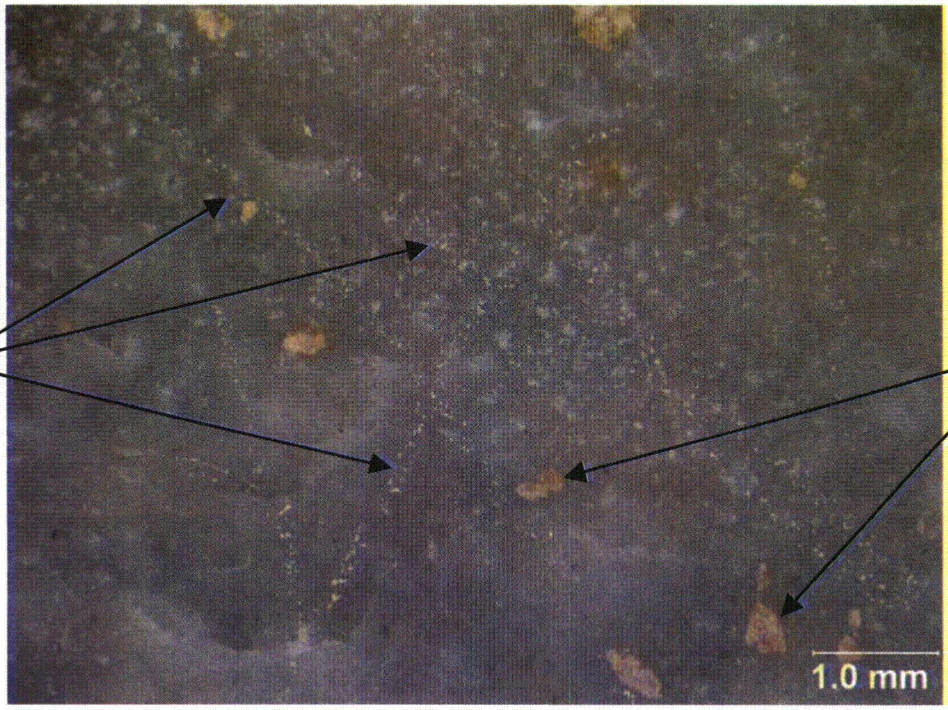

Figure 11. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. Microphotograph of chert nodule (UL-FG-7). Photographed at 10 X magnification.

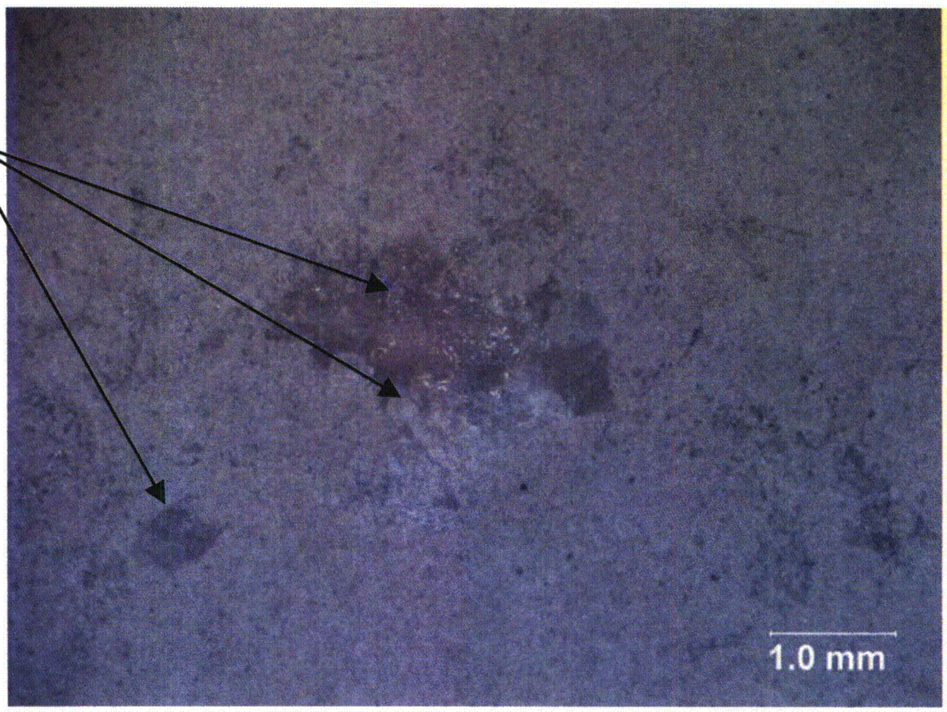

Figure 12. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. Microphotograph of sparry dolomite (UL-FG-1). Photographed at 10X magnification.

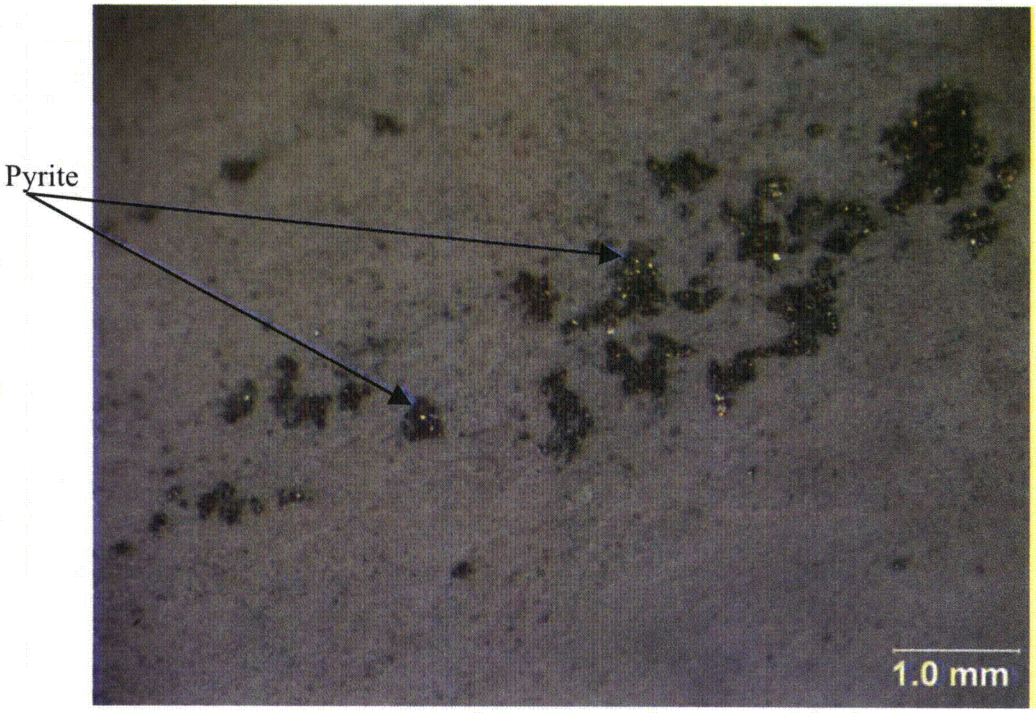

Figure 13. Shawnee Stone, Cyprus Quarry, Upper Level – Fine-Grained. Microphotograph of pyrite in argillaceous dolomitic limestone (UL-FG-7). Photographed at 10X magnification.