Technical Report

Title:	***CERCHAR Abrasivity Testing of Argillaceous Limestone of the Cobourg Formation***
Document ID:	**TR-07-04**
Author:	**Sean Maloney, MIRARCO/ Geomechanics Research Centre, Laurentian University**
Revision:	**2**
Date:	**May 18, 2010**

DGR Site Characterization Document
Intera Engineering Project 06-219

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Document Revision History		
Revision	Effective Date	Description of Changes
0	November 8, 2007	Initial Release
1	April 15, 2008	Conversion from Technical Memorandum to Technical Report
2	May 18, 2010	Minor editorial changes in response to NWMO comments

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1 Introduction

Intera Engineering Ltd. has been contracted by the Nuclear Waste Management Organization (NWMO) to implement the Geoscientific Site Characterization Plan (GSCP) for the Bruce nuclear site located on Lake Huron, Ontario. The purpose of this site characterization work is to assess the suitability of the Bruce nuclear site to construct a Deep Geologic Repository (DGR) to store low-level and intermediate-level radioactive waste. The GSCP is described by Intera Engineering Ltd. (2006, 2008a). MIRARCO Mining Innovation, Geomechanics Research Centre of Laurentian University, Sudbury Ontario was contracted by Intera Engineering Ltd. to provide laboratory geomechanical testing services. The objective of the contracted work described in this report was to conduct abrasivity tests of argillaceous limestone of the proposed host formation for the DGR.

This report summarizes the results of a series of abrasivity tests conducted on select specimens of argillaceous limestone principally of the Cobourg Formation provided by Intera Engineering Limited from borehole DGR-2. In total, ten refrigerated and vacuum sealed rock core samples were delivered for this purpose.

Work described in this Technical Report was completed in accordance with Intera Test Plan TP-07-04 – Geomechanical Lab Testing of DGR-1 & DGR-2 Core (Intera Engineering Ltd., 2008b), prepared following the general requirements of the Intera DGR Project Quality Plan (Intera Engineering Ltd., 2009).

2 Background

Rock abrasivity is a characteristic of significance in estimating wear on mechanical excavation equipment such as core bits and disc cutters. While a number of tests have been proposed, the most widely accepted remains the CERCHAR scratch test (West 1989; Plinninger et al, 2003). In this test, a conical steel point of cone angle 90° is slowly drawn 10 mm across the rock surface under a normal, static force of 70 N. A drawing of the test device is presented in Figure 1. The abrasivity is then determined by the wear flat of the steel cone; units of measurement correspond to the diameter of the wear flat in tenths of a millimetre (e.g., a 0.3 mm diameter wear flat yields a measurement of 3). It is generally recommended that five measurements be made and the CERCHAR Abrasivity Index, CAI, be taken as the mean value.

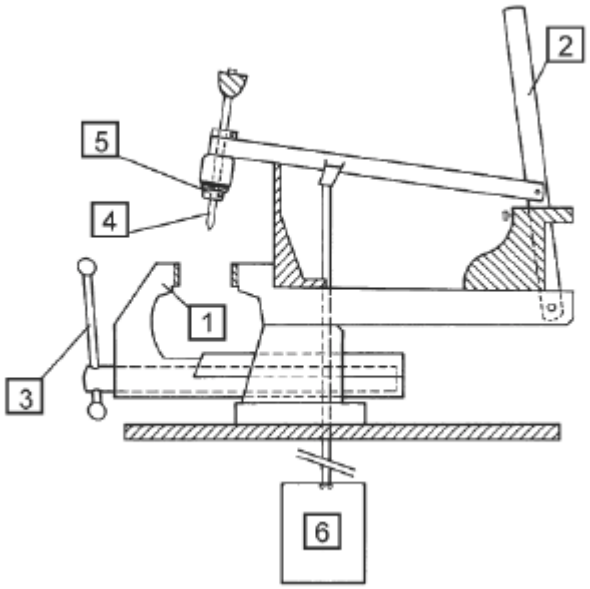

Figure 1 CERCHAR Test Apparatus: 1-3 Sample Vice, 2 Hand Lever, 4 Testing Pin, 5 Pin Chuck and 6 Weight (adapted from Plinninger et al., 2003)

Studies by Plinninger et al. (2003) on the influence of surface conditions showed that CAI values obtained from 'rough' surfaces were about 0.5 higher than those from smooth surfaces. The authors recommended that for rock samples that have unsuitable sample surfaces after breaking, a diamond saw be used for surface formatting and the test result corrected according to the following expression:

$$CAI = 0.99CAI_s + 0.48$$

where CAI_s represents the index obtained from the smooth surface.

3 Methodology

3.1 Sample Collection and Descriptions

Core samples from DGR-2 were collected by Intera Engineering Ltd. following the collection and preservation requirements outlined in Test Plan TP-06-10 – DGR-1 & DGR-2 Core Sampling and Distribution for Laboratory Testing (Intera Engineering Ltd., 2007b). Cores were collected from the proposed DGR host rock argillaceous limestone of the Lower Member of the Cobourg Formation and vacuum preserved with PE and aluminum foil bags.

Because the identification of gradational formation contacts is imprecise in the field and was not finalized until after completion of the testing described in this Technical Report, some samples collected from stratigraphically similar formations located slightly above and below the Cobourg Formation were also subject to abrasivity testing.

Table 1 summarizes the formations and descriptions of DGR-2 core samples subject to CERCHAR abrasivity testing and described in this report.

Table 1 Summary of Geological Formations and Descriptions for DGR-2 Abrasivity Samples

Sample Identifier	Formation	Core Sample Description
DGR2-657.86	Collingwood Member, Cobourg Formation	Dark grey calcareous shale with argillaceous limestone interbeds
DGR2-660.59	Lower Member, Cobourg Formation	Light grey fossiliferous argillaceous limestone
DGR2-663.64	Lower Member, Cobourg Formation	Grey fossiliferous argillaceous limestone
DGR2-667.03	Lower Member, Cobourg Formation	Medium grey mottled and fossiliferous argillaceous limestone
DGR2-672.24	Lower Member, Cobourg Formation	Grey fossiliferous argillaceous limestone with shale interbeds
DGR2-677.32	Lower Member, Cobourg Formation	Grey argillaceous limestone with shale interbeds
DGR2-681.18	Lower Member, Cobourg Formation	Grey argillaceous limestone
DGR2-684.30	Lower Member, Cobourg Formation	Grey mottled and fossiliferous argillaceous limestone
DGR2-690.31	Sherman Fall Formation	Mottled grey argillaceous limestone
DGR2-695.34	Sherman Fall Formation	Grey argillaceous limestone with shale interbeds

3.2 Sample Preparation

The samples were sealed, refrigerated and unopened until needed for testing. All processes were undertaken sequentially on a single specimen to minimize the time of exposure prior to testing (Intera Engineering Ltd., 2008b). When breaking to expose a fresh surface of a sample for testing, the breaks were quite uneven and deemed unacceptable. Consequently, the specimens were wet diamond sawn to create a fresh cut surface for testing which was then dry sanded smooth to remove any surface roughness resulting from the cutting process. Each core segment was confined in a plastic sleeve (see Figure 2) to ensure integrity during cutting.

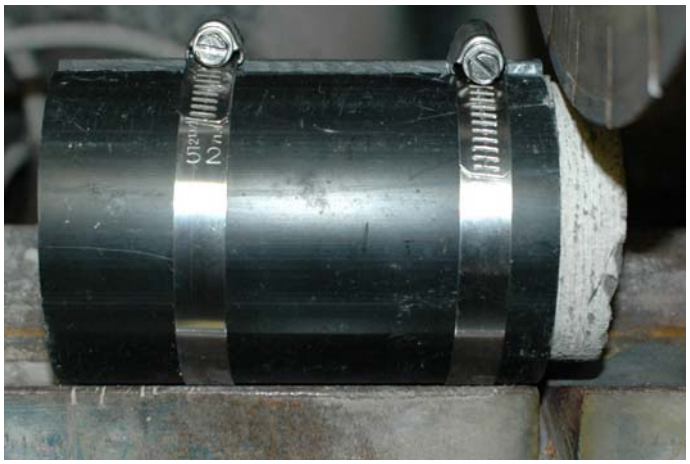

Figure 2 Sleeve to Maintain Specimen Integrity During Cutting Operations

3.3 Sample Testing

Each sample was clamped in position with the smooth, test surface horizontal. A plastic sleeve was again used to mitigate damage from the vice jaws. A new pin was placed in the chuck and carefully brought to bear against the surface under the prescribed load of 70N. The pin was then drawn across the surface for a distance of 10mm. It was then removed for inspection, the sample repositioned and the test repeated an additional four times for each specimen.

Each pin was then subject to two independent measurements of the wear flat using a Wild M38 binocular microscope with a measuring ocular at 40X magnification. All pins and the test surface were photographed for archival purposes (see Appendix).

4 Results

The abrasivity values determined from the testing of the ten samples were quite consistent as shown in Table 2. Individual CAI_s values ranged from a low of 0.25 to a high of 1.75; the mean and standard deviation are 0.86 and 0.30 respectively. CAI values correspondingly ranged from 0.73 to 2.21 with a mean of 1.34 and a standard deviation of 0.3. Histograms of the results are presented in Figure 3.

For comparative purposes, a rough surface specimen from DGR2-684.3 was tested. The results from this test are appended to Table 2. With the exception of the two high values obtained from the smooth surface (Trials 2 and 3), these rough surface results are consistent with the uncorrected smooth results. This suggests that the

smooth test results are likely representative without correction. Plinninger et al. (2004) indicate that tests on rough and saw-cut surfaces yield similar results in materials with low CAI values.

The results obtained are consistent with published data for similar rock types as demonstrated in Figure 4. According to the criteria established by CERCHAR (1986) this argillaceous limestone would be classified as slightly abrasive based upon the CAI_s values and medium abrasive on CAI values.

Table 2 Abrasivity Test Results

Sample ID	Trial #	Wear Flat (mm)	CAI_s	CAI
	1	0.075	0.75	1.22
	2	0.063	0.63	1.10
DGR2-657.86	3	0.050	0.50	0.98
	4	0.100	1.00	1.47
	5	0.063	0.63	1.10
	avg.		**0.70**	**1.17**
	1	0.075	0.75	1.22
	2	0.050	0.50	0.98
DGR2-660.59	3	0.025	0.25	0.73
	4	0.088	0.88	1.35
	5	0.038	0.38	0.85
	avg.		**0.55**	**1.02**
	1	0.075	0.75	1.22
	2	0.088	0.88	1.35
DGR2-663.64	3	0.063	0.63	1.10
	4	0.050	0.50	0.98
	5	0.088	0.88	1.35
	avg.		**0.73**	**1.20**
	1	0.113	1.13	1.59
	2	0.075	0.75	1.22
DGR2-667.03	3	0.088	0.88	1.35
	4	0.100	1.00	1.47
	5	0.088	0.88	1.35
	avg.		**0.93**	**1.40**
	1	0.100	1.00	1.47
	2	0.100	1.00	1.47
DGR2-672.24	3	0.088	0.88	1.35
	4	0.113	1.13	1.59
	5	0.075	0.75	1.22
	avg.		**0.95**	**1.42**

Table 2 Abrasivity Test Results (continued)

	1	0.100	1.00	1.47
	2	0.113	1.13	1.59
DGR2-677.32	3	0.088	0.88	1.35
	4	0.050	0.50	0.98
	5	0.038	0.38	0.85
	avg.		**0.78**	**1.25**
	1	0.075	0.75	1.22
	2	0.138	1.38	1.84
DGR2-681.18	3	0.063	0.63	1.10
	4	0.100	1.00	1.47
	5	0.088	0.88	1.35
	avg.		**0.93**	**1.40**
	1	0.088	0.88	1.35
	2	0.150	1.50	1.97
DGR2-684.3	3	0.163	1.63	2.09
	4	0.050	0.50	0.98
	5	0.063	0.63	1.10
	avg.		**1.03**	**1.49**
	1	0.088	0.88	1.35
	2	0.063	0.63	1.10
DGR2-690.31	3	0.113	1.13	1.59
	4	0.175	1.75	2.21
	5	0.100	1.00	1.47
	avg.		**1.08**	**1.54**
	1	0.088	0.88	1.35
	2	0.113	1.13	1.59
DGR2-695.34	3	0.100	1.00	1.47
	4	0.113	1.13	1.59
	5	0.088	0.88	1.35
	avg.		**1.00**	**1.47**
	1	0.075	0.75	
	2	0.038	0.38	
DGR2-684.3 Rough	3	0.063	0.63	
	4	0.050	0.50	
	avg.		**0.56**	

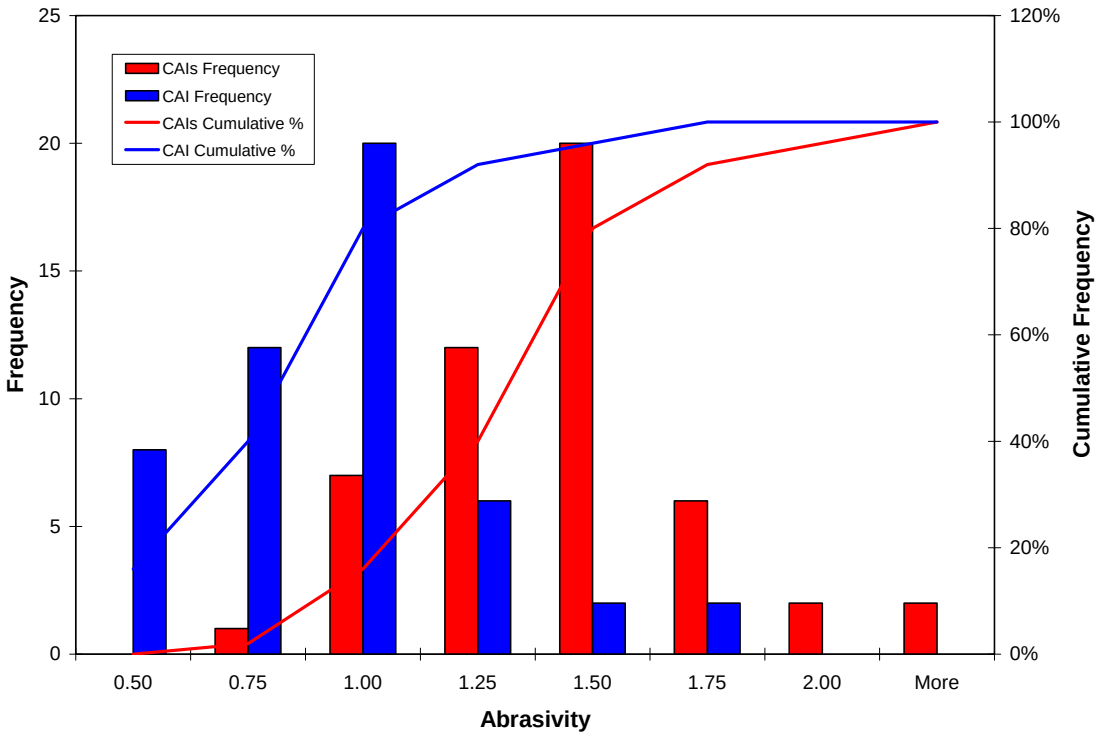

Figure 3 Histogram of Abrasivity Values

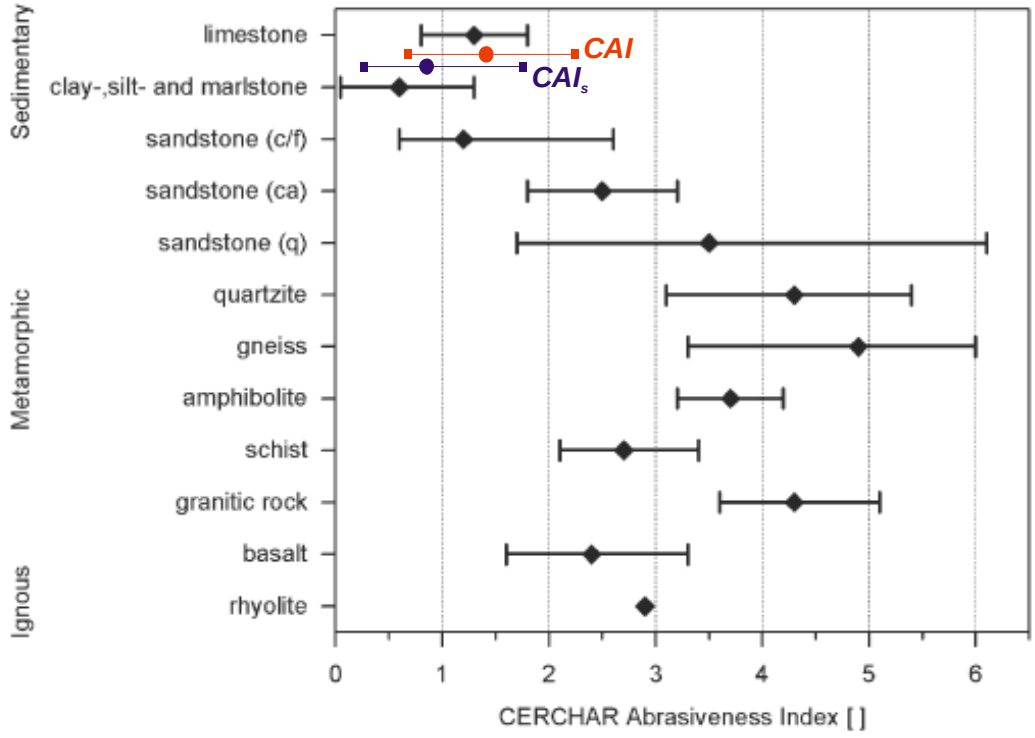

Figure 4 Comparison of Test Results (Coloured) with Compilation of Typical CAI Values (adapted from Plinninger et al 2003)

5 Data Quality and Use

Data on Cobourg Formation abrasivity described in this Technical Report are based on testing conducted on preserved DGR-2 core samples following established and well defined CERCHAR abrasivity index testing procedures.

The results obtained are consistent with published results for similar rock types and indicate that the data are suitable for assessment of the abrasiveness of the formations and estimation of wear on mechanical excavation equipment.

6 References

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7 Acknowledgments

The assistance of David Landry and Michel Seguin of MIRARCO in the execution of this test program is gratefully acknowledged.

APPENDIX A

Photographic Record of Testing


DGR2 - 657.86
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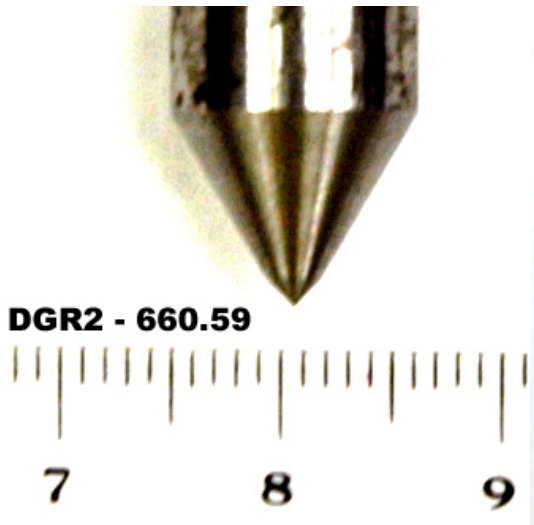
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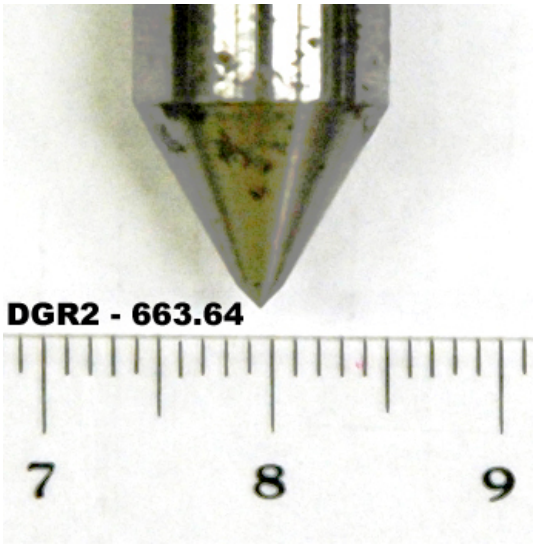
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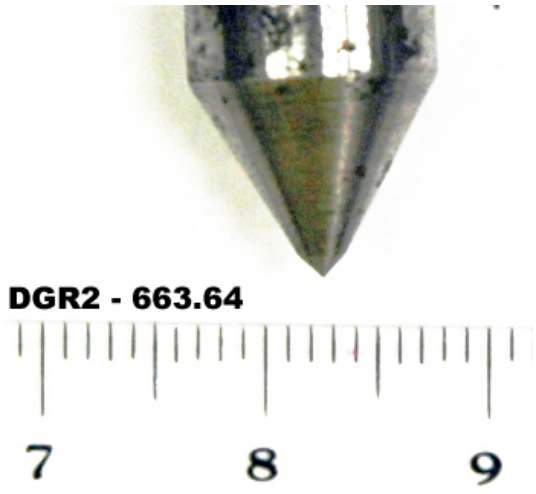
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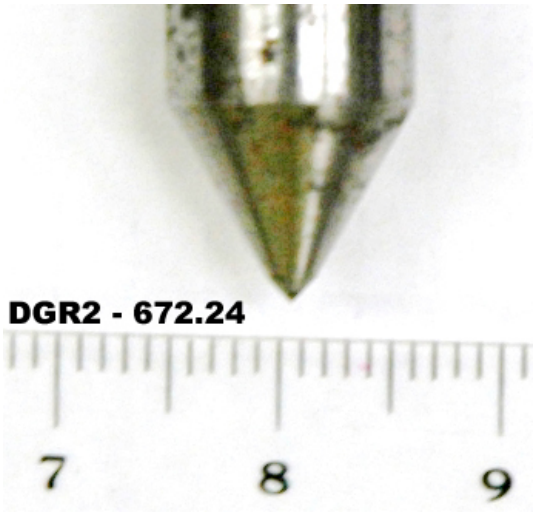
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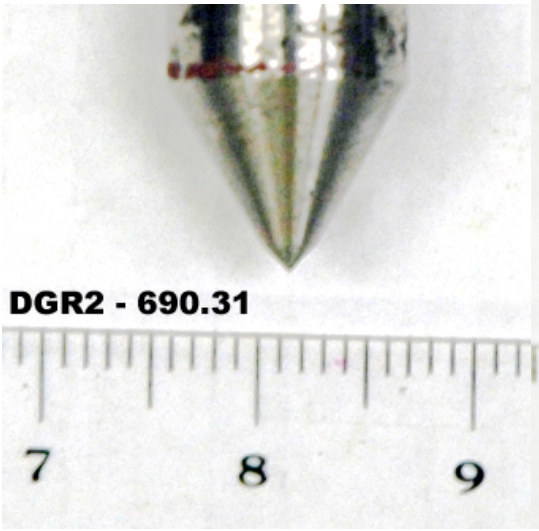
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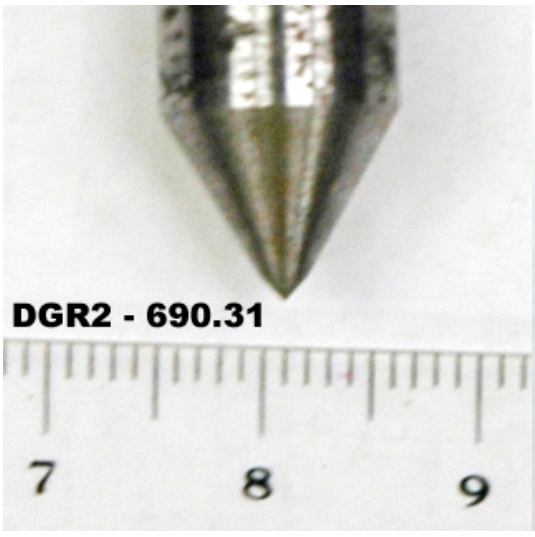
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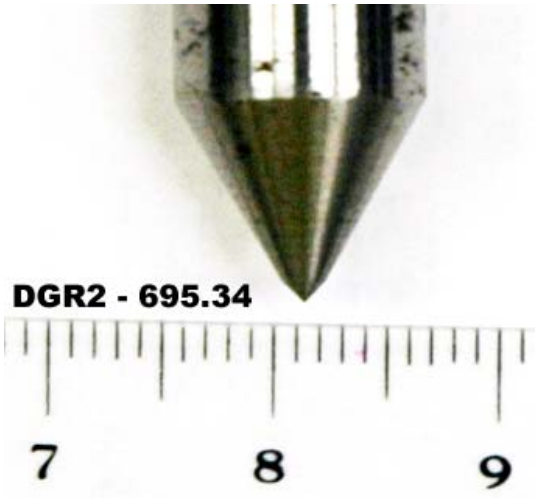
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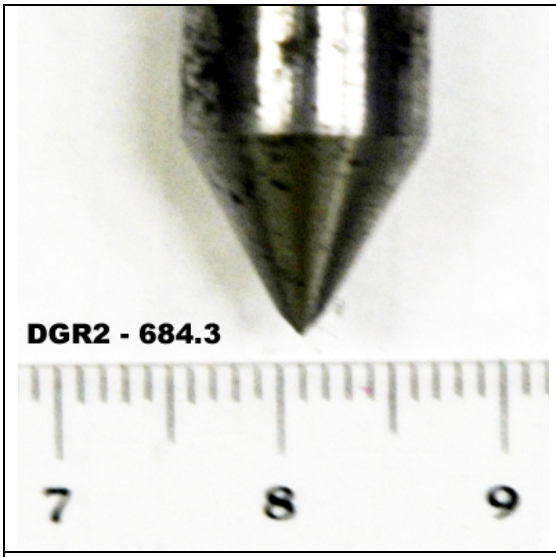

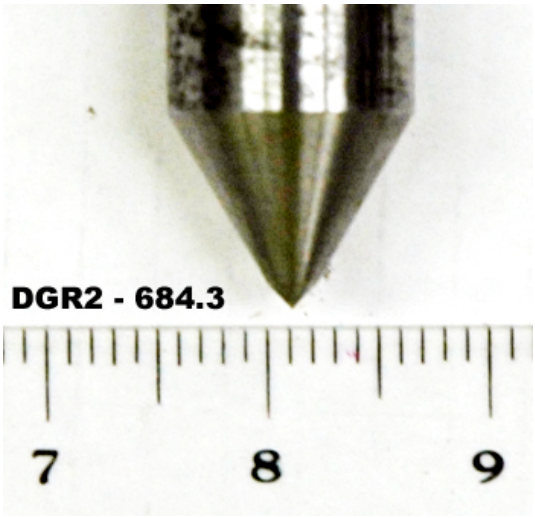

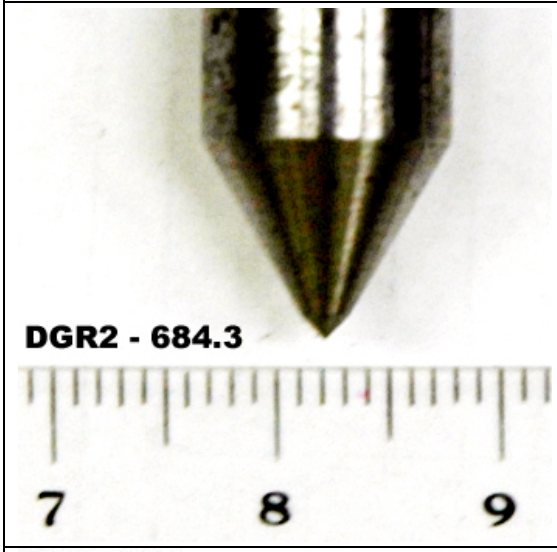

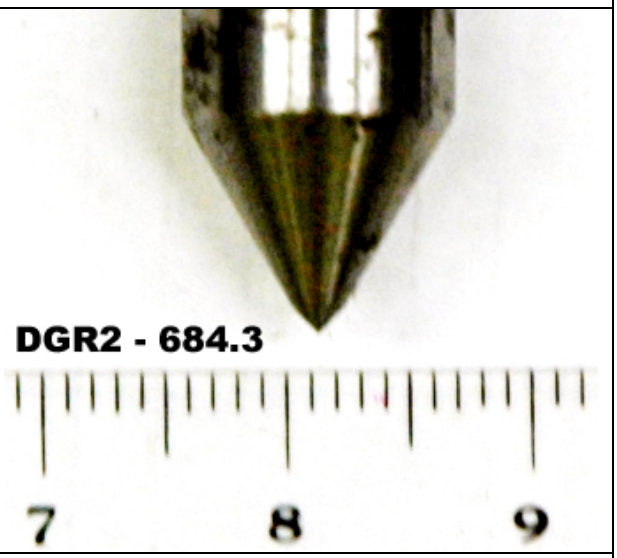

Tests on rough surface