The Effects of Heat on Some Common Vermont Lithic Materials

by Matthew T. Boulanger and Allen D. Hathaway

Introduction

The benefits of heat treatment (the intentional heating of raw materials to increase workability) were first documented by Crabtree and Butler (1964). Subsequent work has confirmed that intentional and unintentional exposure to heat can alter siliceous stone macroscopically and microscopically (Luedtke 1992). Obvious effects of heat can include noticeable changes in color, luster, and workability. Intentional heating of chert can therefore produce results beneficial to the production of stone tools. Unintentional heating of stone debitage should produce similar changes. Such changes, specifically alteration of color and luster, may lead to misidentification of waste flakes recovered from hearth contexts. Therefore, this study seeks to identify some heat-induced changes of varieties of chert and quartzite commonly used throughout Vermont's prehistory. Such information is necessary in order to correctly identify and interpret debitage recovered from hearth contexts.

Past Studies

Little study has been done to document the effects of heat on stone commonly used by Vermont's Native American populations. Several authors have conducted surveys of lithic materials available in Vermont (Georgiady and Brockmann 2002; Noel 1977; Paquin 1986a); however, none of these authors attempted to identify heat-induced changes of the surveyed lithic materials. Petersen et al. (1983) examined lithic materials recovered from the Winooski site (VT-CH-46) during the process of nominating it to the National Register of Historic Places. The authors presented 15 general categories, based on macroscopic characteristics, as potential source groups for stone artifacts recovered from Winooski. Descriptions of heat-induced changes are included in these descriptions, although experimental conditions and controls are not provided.

Lithic Sources and Materials

Virtually all of Vermont's known quarry sites are located within the Champlain Valley, although it must be stated that a comprehensive survey of such sites has never been completed. In this study we address lithic material gathered from four locales, representing three geological formations.

Hathaway Chert

Doll et al. (1961) identified the Hathaway formation as a "gray to black argillite and bedded radiolarian chert." Perhaps the best known Native American quarry of the Hathaway formation is the Brooks Farm Quarry (VT-FR-2) in the Town of St. Albans (Bolton 1930; Boulanger et al. 2005; Ross 1932). Chert from this quarry exhibits a wide variety of macroscopic characteristics and can range from a dull, flat luster to a glassy sheen. Both argillite and chert from the quarry can range from brittle and platy to siliceous and glassy. A variety of colors has been recorded in the stone from VT-FR-2 including black, brown, gray, green, and red. Petersen et al. (1983) classify chert from the Hathaway formation within their "Black Chert" group and identify internal and pot-lid fracturing, and reddish color as heat-induced changes. Samples from two Hathaway outcrops, one a known quarry and the other a possible quarry, were collected and are used in this study.

Lazy Lady Island (VT-FR-22)

Lazy Lady Island was identified as a potential Native American chert quarry in 1986 and is designated VT-FR-22 in the Vermont Archeological Inventory (Paquin 1986b). The privately owned island is located in Saint Albans Bay in the Town of Georgia, Franklin County. The authors obtained permission to examine the island for Native American quarry activity and identified chert extraction areas and several workshops. Chert from the quarry is generally very dark gray (Munsell Value N 3/ [GretagMacbeth 1998]), with olive, green, and light gray (N 5/) mottling and streaking. The chert has a slightly waxy luster and weathers to a chalky gray-white color.

Kill Kare State Park

Hathaway-formation chert is also readily available within portions of Kill Kare State Park, near the tip of Hathaway Point in St. Albans. Though not specifically identified as a Native American stone quarry in the Vermont Archeological Inventory, local collectors, avocational archaeologists, and professional archaeologists have reported finding chert flakes and possible artifacts

throughout the park (Frink 1987). The authors obtained several black- to dark-gray (N 2.5/ - N 3/) nodules from the park. Texturally, the chert ranges from argillaceous to glossy with good conchoidal fracture. Samples of both the brittle, platey chert (Hathaway I) and the glassier, fine-grained chert (Hathaway II) are used in this study.

Mount Independence Chert

Black chert found at Mount Independence, in the Town of Orwell, was used prehistorically by Native Americans and historically by European Americans (Seidel et al. 1997). Several chert-bearing dolomite formations are present on the Mount—the Whitehall, Ticonderoga, and the Cuttings (Doll et al. 1961; Donovan and Mango, 2002; Welby 1961). These three formations are lithologically similar, and they comprise the lower basal sequence of the autochthonous Champlain Valley geological sequence. Based on the widespread quarry activity observed at the site, it is likely that Native Americans used chert from all three of these formations to varying degrees. Chert samples originating from both Native American and European American quarry areas are used in this study.

Macroscopically, chert from Mount Independence is identified by its blue-black color, pyrite inclusions, and slightly grainy appearance (Noel 1977). Samples used in this study are generally dark gray (N 3/ – N 4/). Macroscopically visible inclusions of pyrite were present in some, but not all, of the samples. Chert samples from the European American gunflint quarry appear to have undergone different diagenic processes, evidenced by the presence of vugs, folds, inclusions of recrystallized quartz and dolomite, and generally poor fracture. Chert samples from the Native American extraction area are somewhat translucent and exhibit good conchoidal fracture. Petersen et al. (1983) include Mount Independence chert within their "Black Chert" group, the same designation given to Hathaway chert.

Cheshire Quartzite

Perhaps the most common lithic material encountered in pre-contact Vermont archaeology is a blue-gray-white quartzite from the Cheshire formation. Although much of the formation is composed of a phyllite unsuitable for flaked-stone-tool manufacture, a vitreous quartzite is found at the base of the formation.

The Cheshire formation is situated in a distinct north–south band on the western side of the state, representing the bulk of the Green Mountains. Native American quartzite quarries within the Cheshire formation are known throughout the Green Mountains, ranging from the center of Vermont near the town of Bristol, south-central Vermont near Wallingford, and southern Vermont near Bennington (Lacy 1997; Noel 1977). Study samples come from the Black Brook Quarry (VT-RU-105) identified by Lacy (1997). No thermal-induced changes of Cheshire quartzite are identified by Peterson et al. (1983).

Procedures

Samples were selected by comparing descriptions of each formation in archaeological and geological (Doll et al. 1961; Hawley 1957; Welby 1961) literature. When possible, samples that showed clear evidence of past use (e.g., flake scars) were selected from the available quarry debris.

Over thirty small retouch flakes were driven off each sample. Flakes were removed with the tine of a deer antler, in a manner commonly referred to as pressure flaking. Flakes were collected and placed in individual containers with corresponding identification numbers; all unused material was retained for future testing. Five flakes from each type of stone were weighed, placed into spun-silica CEM crucibles, and inserted directly into a pre-heated laboratory furnace to simulate the falling of flakes into an open fire (typical laboratory furnace is about a cubic-foot). Three experimental series were conducted for specific lengths of time and at controlled temperatures to simulate a range of conditions (Table 1).

Table 1. Conditions of the three experimental series used in this study.

Experimental Series	Temperature (Centrigrade)	Duration (hours)
Series 1	600	1
Series 2	800	1
Series 3	600	3.5

After the specified amount of time, the furnace was turned off and allowed to cool to room temperature. Flakes were removed from the furnace, weighed, and examined. Each flake and control sample was then compared to standard Munsell color charts, and a best-fit choice was selected for each sample.

Results

The heating process produces a measurable shift in the color of all cherts from the Hathaway formation. In all

instances where exposed to heat, Hathaway chert shows a measurable increase in hue—toward red (Tables 2, 3, and 4). Neither series 1 nor series 2 produced dramatically different results in the Hathaway chert, but both series did produce noticeable increases in hue. Series 3 of the experiment revealed a greater overall shift in the hue and value from the original color.

The same process of heating did not produce measurable color changes in cherts from Mount Independence, with the exception of sample numbers 214 and 311. Visible impurities within these two samples exhibited noticeable color shifts, although the surrounding ground mass did not.

Cheshire quartzite was affected by the heating process in all three series. The quartzite exhibited no change in hue or chroma on the Munsell scale, but increased in value—became lighter. All samples of the quartzite increased in translucency after exposure to heat.

Conclusions

Following Luedtke (1992), heat-induced color change of chert is believed to result from iron oxidization. The observed changes in these Vermont chert samples suggest that Hathaway-formation cherts are richer in iron compared to those from Mount Independence. In a previous study utilizing x-ray fluorescence, Burke (1997) determined that Hathaway cherts are generally higher in iron content than those of the nearby Clarendon Springs formation, a lateral facies of the formations present at Mount Independence. The results of this study suggest that, like Clarendon Springs cherts tested by Burke, the chert found at Mound Independence is relatively low in iron.

This initial study has shown that even short-duration exposures to hearthlike temperatures can noticeably change the macroscopic appearance of stone flakes, specifically those originating from the Hathaway and Cheshire formations. In the case of Hathaway chert, duration of heat exposure is a greater variable than temperature alone, and we propose that extended exposure to heat will cause the chert to appear significantly more red than it does in a natural state. Further, Cheshire quartzite becomes both lighter and more translucent when heated. Once heated, the quartzite assumes the appearance of quartz.

Additional studies are needed to determine the microscopic and more qualitative effects of intentional and unintentional heat treatment on these stone materials. It remains to be seen whether the identified changes are sufficient to confuse archaeologists; however, based on the change of color observed in this study, we recommend a cautious approach for those attempting to visually characterize stone artifacts from hearth contexts.

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Matthew T. Boulanger works at the Archaeometry Laboratory at the Missouri University Research Reactor, and is a graduate student in the Department of Anthropology at the University of Missouri-Columbia. Prior to moving to the Midwest, Matt worked for Archaeology Consulting Team in Essex Junction, and he served on the VAS Board of Trustees. His interests are in materials analysis, natural and cultural geography, and computer applications in archaeology. His current research involves using geochemical analysis of lithic and ceramic artifacts to better understand the Native cultures of New England. He can be reached by email at: boulangerm@missouri.edu or matthewboulanger@mac.com.

Allen D. Hathaway was a member of Archaeology Consulting Team, Inc. of Essex Junction, VT, from 1995 to 2005. His interests are in the application of GPS, GIS, databases and statistical analysis to archaeological research.

Table 2. Results of Series 1 of the heating experiment. All samples were inserted into a laboratory furnace pre-heated to 600° Centigrade and left for 1 hour.

			Before heat treatment		After Heat Treatment	
Sample	Material	Formation	Munsell Value	Color Name	Munsell Value	Color Name
101	Chert	Hathaway II	N 2.5/	Black	7.5YR 2.5/1	Black
102	Chert	Hathaway II	N 2.5/	Black	7.5YR 2.5/1	Black
103	Chert	Hathaway II	N 2.5/	Black	5YR 4/1	Dark Gray
104	Chert	Hathaway II	N 2.5/	Black	5YR 3/1	Very Dark Gray
105	Chert	Hathaway II	N 2.5/	Black	5YR 4/1	Dark Gray
106	Chert	Hathaway I	N 3/	Very Dark Gray	2.5YR 4/1	Dark Reddish Gray
107	Chert	Hathaway I	N 3/	Very Dark Gray	2.5YR 4/1	Dark Reddish Gray
108	Chert	Hathaway I	N 3/	Very Dark Gray	5YR 4/1	Dark Gray
109	Chert	Hathaway I	N 3/	Very Dark Gray	5YR 4/1	Dark Gray
110	Chert	Hathaway I	N 3/	Very Dark Gray	5YR 2.5/1	Black
111	Chert	Mt. Independence I	N 4/	Dark Gray	N 3/	Very Dark Gray
112	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/	Dark Gray
113	Chert	Mt. Independence I	N 4/	Dark Gray	N 3/	Very Dark Gray
114	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/	Dark Gray
115	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/	Dark Gray
116	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray	5YR 3/1	Very Dark Gray
117	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	5YR 3/1	Very Dark Gray
118	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	5YR 3/1	Very Dark Gray
119	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	5YR 2.5/	Black
120	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	2.5YR 3/1	Dark Reddish Gray
121	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
122	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
123	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
124	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
125	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
126	Chert	Lazy Lady II	N 5/	Gray	7.5YR 3/1	Very Dark Gray
127	Chert	Lazy Lady II	N 5/	Gray	7.5YR 3/1	Very Dark Gray
128	Chert	Lazy Lady II	N 5/	Gray	7.5YR 3/1	Very Dark Gray
129	Chert	Lazy Lady II	N 5/	Gray	7.5YR 3/1	Very Dark Gray
130	Chert	Lazy Lady II	N 5/	Gray	7.5YR 3/1	Very Dark Gray
131	Chert	Mt. Independence II	N 3/	Very Dark Gray	N 3/	Very Dark Gray
132	Chert	Mt. Independence II	N 3/	Very Dark Gray	N 3/	Very Dark Gray
133	Chert	Mt. Independence II	N 3/	Very Dark Gray	N 3/	Very Dark Gray
134	Chert	Mt. Independence II	N 3/	Very Dark Gray	N 3/	Very Dark Gray
135	Chert	Mt. Independence II	N 3/	Very Dark Gray	N 3/	Very Dark Gray
136	Chert	Mt. Independence III	N 4/	Dark Gray	N 4/	Dark Gray
137	Chert	Mt. Independence III	N 4/	Dark Gray	N 4/	Dark Gray
138	Chert	Mt. Independence III	N 4/	Dark Gray	N 4/	Dark Gray
139	Chert	Mt. Independence III	N 4/	Dark Gray	N 5/	Gray
140	Chert	Mt. Independence III	N 4/	Dark Gray	N 4/	Dark Gray

Table 3. Results of Series 2 of the heating experiment. All samples were inserted into a laboratory furnace pre-heated to 800° Centigrade and left for 1 hour.

			Before heat treatment		After Heat Treatment	
Sample	Material	Formation	Munsell Value	Color Name	Munsell Value	Color Name
201	Chert	Hathaway II	N 2.5/	Black	10R 4/2	Weak Red
202	Chert	Hathaway II	N 2.5/	Black	2.5YR 4/2 to 5YR 3/2	Weak Red to Dark Reddish Brown
203	Chert	Hathaway II	N 2.5/	Black	5YR 4/2	Dark Reddish Gray
204	Chert	Hathaway II	N 2.5/	Black	2.5YR 3/1	Dark Reddish Gray
205	Chert	Hathaway II	N 2.5/	Black	5YR 4/1	Dark Gray
206	Chert	Hathaway I	N 3/	Very Dark Gray	10R 4/2	Weak Red
207	Chert	Hathaway I	N 3/	Very Dark Gray	2.5YR 4/1	Dark Reddish Gray
208	Chert	Hathaway I	N 3/	Very Dark Gray	2.5YR 5/4 with 10R 3/2 Banding	Reddish Brown with Dusky Red Banding
209	Chert	Hathaway I	N 3/	Very Dark Gray	5YR 4/1	Dark Gray
210	Chert	Hathaway I	N 3/	Very Dark Gray	5YR 3/1	Very Dark Gray
211	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/	Dark Gray
212	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/	Dark Gray
213	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/	Dark Gray
214	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/ with N 7/ Banding	Dark Gray with Light Gray Banding
215	Chert	Mt. Independence I	N 4/	Dark Gray	N 5/	Gray
216	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	5YR 4/1	Dark Gray
217	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	2.5YR 3/2	Dusky Red
218	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	5YR 3/2	Dark Reddish Brown
219	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	5YR 4/2	Dark Reddish Gray
220	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray	5YR 3/2	Dark Reddish Brown
221	Quartzite	Cheshire	N 7/	Light Gray	N 7/ to N 8/	Light Gray to White
222	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
223	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
224	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
225	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White

Table 4. Results of Series 3 of the heating experiment. All samples were inserted into a laboratory furnace pre-heated to 600° Centigrade and left for 3.5 hours.

			Before heat treatment		After Heat Treatment	
Sample	Material	Formation	Munsell Value	Color Name	Munsell Value	Color Name
301	Chert	Hathaway II	N 2.5/	Black	10R 4/1	Dark Reddish Gray
302	Chert	Hathaway II	N 2.5/	Black	10R 3/1	Dark Reddish Gray
303	Chert	Hathaway II	N 2.5/	Black	10R 4/1	Dark Reddish Gray
304	Chert	Hathaway II	N 2.5/	Black	10R 4/1 with 10R 2.5/1 Band	Dark Gray with Reddish Black Band
305	Chert	Hathaway II	N 2.5/	Black	10R 3/1	Dark Reddish Gray
306	Chert	Hathaway I	N 3/	Very Dark Gray	10R 4/1	Dark Reddish Gray
307	Chert	Hathaway I	N 3/	Very Dark Gray	10R 4/1	Dark Reddish Gray
308	Chert	Hathaway I	N 3/	Very Dark Gray	2.5YR 2.5/1	Reddish Black
309	Chert	Hathaway I	N 3/	Very Dark Gray	10R 3/1	Dark Reddish Gray
310	Chert	Hathaway I	N 3/	Very Dark Gray	10R 4/1	Dark Reddish Gray
311	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/ with 2.5YR 5/8 Impurities	Dark Gray with Red Impurities
312	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/	Dark Gray
313	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/	Dark Gray
314	Chert	Mt. Independence I	N 4/	Dark Gray	N 3/	Very Dark Gray
315	Chert	Mt. Independence I	N 4/	Dark Gray	N 4/	Dark Gray
316	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	N 4/ with 7.5R 3/2 Banding	Dark Gray with Dusky Red Banding
317	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	N 3/ with 7.5R 4/3 Banding	Very Dark Gray with Weak Red Banding
318	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	N 4/ with 10R 3/2 Mottling	Dark Gray with Dusky Red Mottling
319	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	2.5YR 3/1	Reddish Brown
320	Chert	Lazy Lady I	N 3/ with N 5/ Mottling	Very Dark Gray with Gray Mottling	2.5YR 3/1	Reddish Brown
321	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
322	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
323	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
324	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White
325	Quartzite	Cheshire	N 7/	Light Gray	N 8/	White