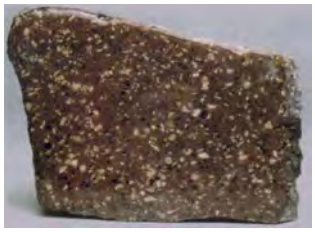
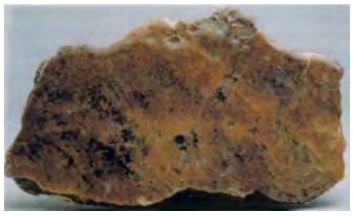
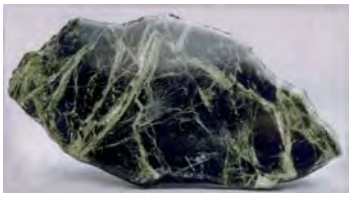
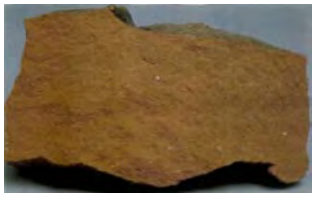


Dimension Stone Feasibility Study








Development Potential in Michigan's Upper Peninsula

H. James Bourque and Associates
402 Ashmun Street, P.O. Box 292
Sault Ste. Marie, MI 49783 (906) 635-9191

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Jim Bourque
H. James Bourque and Associates

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H. James Bourque and Associates

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H. James Bourque and Associates

Doug Rothwell
Michigan Jobs Comission

Douglas Stites
Michigan Jobs Commission

Tom Freeman
Michigan Jobs Commission
Advisory Board Member

Jim Donaldson
Michigan Jobs Commission
Advisory Board Member

Cathi Cole
Michigan Jobs Commission
Advisory Board Member

Kim Stoker
Western Upper Peninsula Planning and Development Region
Advisory Board Member

Jim Stingle
Western Upper Peninsula Planning and Development Region
Advisory Board Member

David Gillis
Central Upper Peninsula Planning and Development Region Advisory Board Member

John Campbell
Eastern Upper Peninsula Planning and Development Region Advisory Board Member

Dr. Allan Johnson
Michigan Technological University
Advisory Board Member

Dr. Lewis Brown
Lake Superior State University

Milt Gere
Michigan Department of Natural Resources, Advisory Board Member

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Michigan Technological University

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Project Background

Dimension stone is not new to the Upper Peninsula of Michigan, however, up until approximately two years ago (spring of 1997) very little was known or remembered about this once flourishing industry. Remnants of this once great industry, which existed from approximately 1870 to 1915, are present in the architecture of many unique sandstone buildings in communities throughout the Lake Superior region.

Some 32 sandstone quarries were in existence in varying times during this period. History indicates that the first major sandstone quarries that produced commercial grade stone were located in the areas of Marquette and Jacobsville (southeast of Lake Linden). The town of Jacobsville was named after John Henry Jacobs, one of the leading developers of the sandstone industry in the Upper Peninsula. See Figure 1 for an example of a typical sandstone quarry during this time period.

The colors were quite exquisite, ranging from a red/white variegated to a deep brown to a bright red. This sought-after stone reached markets throughout the central United States, being incorporated into buildings in Milwaukee, Chicago, Detroit, and Cleveland. The stone even reached eastern Atlantic ports such as Boston and New York. For a period of time, stone was even shipped to England for use in construction of many important buildings. (For more information on the history of the sandstone industry, see Appendix A- excerpts from Dr. Kathryn Bishop Eckert's report, The Sandstone Architecture Of The Lake Superior Region, 1982.)

For many years, quarriers, architects, and builders have been intrigued by the unique architecture of the many sandstone buildings that are scattered throughout the U.P. Especially interesting are the unique carvings and facades that had been created with this highly workable stone.

Figure 1. Sandstone quarry, late 1800s, jacobsville. (Photo from MTU Archives and Copper Country Historical Collections, MTU, donated by Roy Drier).

In Recent Years

Enough interest was generated in the past few years in this sandstone that the State of Michigan decided that this valuable resource needed to be re-explored. Not only was the State interested in the historic sandstone industry, but they were also very interested in the potential of utilizing the huge deposit for use as dimension stone.

The State of Michigan was interested in this project for a number of reasons. The top reasons are the following:

1. To redevelop this valuable natural resource

2. The potential of creating many new jobs in both in dimension stone extraction as well as jobs in support and value industries.

This action was timely, because the international and domestic dimension stone industries were growing at an accelerated rate and the prospects of this continued growth were great. It was also learned that high quality sandstone, in particular, was in great demand in the marketplace, especially the colors that are found in the U.P.

It was also known that the states surrounding Michigan, including province of Ontario, were producing far greater amounts of stone than Michigan, even though a greater variety of stone is found throughout Upper Michigan.

In the summer of 1997, the Michigan Jobs Commission funded a study to investigate the potential development of a dimension stone industry in the Upper Peninsula. They contracted with an experienced mining and quarry development consulting firm, H. James Bourque and Associates, of Sault Ste. Marie, Michigan, to develop and conduct the study, which will be known as HJB for the balance of this paper.

Development of this study geared toward providing the information that a potential investor would ask about the stone resources in the Upper Peninsula. HJB agreed to investigate and provide information on the following:

1. Confirm that the prices paid in the dimension stone industry would justify the development of quarries in the Upper Peninsula;

2. To develop, through research, a list of all previous stone sightings- initially 65 sites were described- by the end of the study, the list increased to 97 sites. Each site was located and pinpointed on maps for developers to refer to;

3. Evaluation of each site geologically and its feasibility for development as a dimension stone quarry;

4. Select sites that have the best potential for development- approximately 10 sites;

5. Investigate top sites more intensely- conduct core drilling in selected sites to determine quantity and quality of stone;

6. Contact equipment suppliers and determine the recommended methods for extraction of stone from quarries;

7. Develop a general plan and cost estimate for quarry start-up operation, this will be general in nature, however, it will provide valuable information for investors entering into the dimension stone business for the first time, as well as provide a checklist for experienced operators. Major equipment suppliers have agreed to provide quarry equipment, cost estimates and annual cost estimates for operating a quarry. This will be done on a quarry-by-quarry basis, depending on location and prospects for yield.

Study Methods

HJB began this investigation in the fall of 1997. Little or no information was available to begin the project, with the exception of two documents. The first was a study done in 1972 by Michigan Technological University (MTU), entitled Study of Technical and Economic Aspects of an Expanded Stone Industry in Michigan, written by Dr. Allan Johnson and associate geologists at the university. The study not only discussed the potential for traditional stone uses, but also briefly discussed the potential for use as dimension stone. One of the more valuable sections of the report contained a list of 51 sites that had been visited and evaluated for possible use as industrial stone. The majority of sites cataloged were granite with several sandstone and dolostone sites included as well.

The second document was a doctoral thesis written by Dr. Kathryn Bishop Eckert in 1982, titled The Sandstone Architecture of the Lake Superior Region. This report dealt primarily with the beautiful architecture found in the many sandstone buildings in the communities from Duluth, Minnesota to Sault Ste. Marie, Michigan. In addition to this information, Dr. Eckert investigated many of the historic documents that discussed the development, location, and production of 17 sandstone quarries in Michigan that provided the sandstone for these buildings and others around the turn of the century.

Between the Eckert report and the MTU report, HJB initially started with a list of 65 sites to be found and investigated. This list, through further investigation, was expanded to 97 sites. All sites that had potential were visited on at least one or more occasions and were evaluated. A number were eliminated because of the location and lack of potential for development. The main reason was the proximity of the site to populated areas. Others were eliminated due to the fact that previous observations indicated that the stone was of poor quality or quantity.

Geology of the Upper Peninsula

The geology of the Upper Peninsula has been examined by HJB. The following is a basic overview.

There are extensive sandstone deposits throughout the U.P. This deposit located on the south shore of Lake Superior extends from Sault Ste. Marie, Michigan to Duluth, Minnesota. The formation commonly known as "Jacobsville" sandstone was located primarily west of Marquette.

To the south of this formation are massive limestone and dolomite deposits, which extend from Green Bay to Niagara Falls, in a large arc along the southern portion of the Upper Peninsula. This stone traditionally has been used for chemical and other industrial uses and has been used on a limited basis for dimension stone.

There are also large granite deposits extending from Marquette to Iron Mountain and from the Keweenaw Peninsula to Ironwood, encompassing most of the western portion of the U.P. This is the same area that produced the great wealth in the iron and copper mines of years past. These deposits were never quarried for use as dimension stone (see maps- Figure 2 and Figure 3).

For more detailed information about the specific geology of the area, refer to the Bedrock Geology of Northern Michigan map from the State of Michigan, Department of Natural Resources, 1987.

Figure 2. Map of Michigan. Outlined area indicates area of greatest potential for sandstone and granite.

Figure 3. Areas of greatest interest are circled. They have the highest quality sandstone and granite dimension stone deposits.

Dimension Stone Production

The next several pages will give the reader an overview of dimension stone production both in North America and in Europe. This information will show the reader that dimension stone production is not large compared to traditional aggregate industries, where one aggregate quarry can produce several million tons of stone per year.

The total production for dimension stone quarries, in the United States, was less than 1.5 million tons annually. A great difference between the two is the value of the finished product. As an example, conventional aggregates normally sell for around $10 per ton, whereas dimension stone blocks, at the quarry, would sell upwards of $150 to $200 per ton.

The following figures are intended to acquaint the reader with worldwide and domestic production.

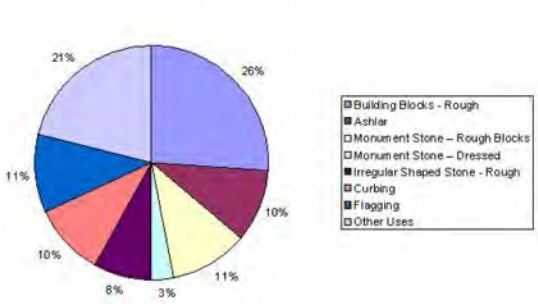
In the most recent report by the USGS, dimension stone production in the United States for 1997 totaled 1.18 million tons valued at $225 million. These numbers reflect the production of 209 out of 273 dimension stone operations that responded to the USGS survey.

Leading producing companies in terms of tonnage in the United States were the following, with a list of the company's quarry locations.

Cold Springs Granite Company: California, Minnesota, South Dakota,Texas
Fletcher Granite Company Inc.: Massachusetts, New Hampshire
Indiana Limestone Company Inc.: Indiana
Oolitic Victor Stone Company: Indiana
Rock of Ages Corp.: Georgia, New Hampshire, Vermont
Valders Stone and Marble, Inc.: Wisconsin
Williams Stone Company: Massachusetts

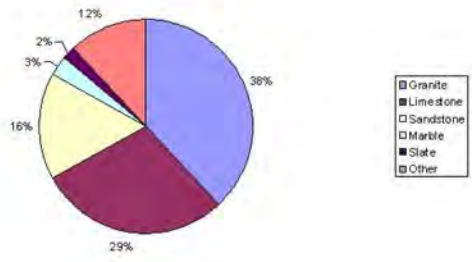
1997 Dimension Stone Production by Types:

1. Of the companies that responded to the survey, GRANITE was produced by 38 companies at 73 locations. Total tonnage produced- 444,000 tons valued at $110 million with a value of $248 per ton f.o.b. the quarry. Cold Spring Granite, Fletcher Granite, and Rock of Ages were the top producers and accounted for more than 50% of domestic production in value and tonnage. Massachusetts produced almost ¼ of the tonnage and more than 17% of the value of the U.S. total.



2. Of the companies that responded to the survey, LIMESTONE was produced by 25 companies at 29locations in 10 states. Total tonnage produced- 345,000 tons valued at $52.3 million with a value of$152 per ton f.o.b. the quarry. Indiana was the leading state in production with 190,000 tons in 1996, followed by Wisconsin, Kansas, and Texas.

Figure 4. 1997 Dimension Stone Usage by Product. Information from USGS.



3. Of the companies that responded to the survey, SANDSTONE was produced by 31 companies at 33locations in 15 states. Total tonnage produced- 187,000 tons valued at $24 million with a value of $128 per ton f.o.b. the quarry. Leading producing states were New York, Arizona, Ohio, and Pennsylvania.

Dimension stone, in its totality, is widely used for a number of purposes. The most predominant are as follows:

Figure 5. 1997 dimension stone production by stone type. Information from USGS.

The leading states that produced dimension stone are: Indiana Georgia Vermont Wisconsin Together these states accounted for 45% of the total nation's output.

Internationally, the United States ranks 11th in production. The top dimension stone producing countries are China, Italy, India, Egypt, and Spain. Stone imported for consumption is almost 2 Y2 times the value of domestic production.

The following are comments taken from one of the national trade journals from the commodity specialist from the USGS:

"Industry experts believe North American firms are more likely to be successful in the 1990's when a large portion of their sales are in fast-growing niche markets: granite and marble in kitchens and bathrooms, limestone in landscaping stone and ledges, hand-carved or worked stone in custom built houses, and perhaps, limestone tiles. The trend is continuing for the use of "natural stone" to provide a rustic earthy setting. This includes acid-washed stone and other stones that are harder to take a polish. Annual growth rates through this decade have been projected to be 2.6% for granite, 3.7% for limestone, 3.8 to 5% for slate and 2.0 to 4.5% for marble."

At another time, the commodities specialist said: "Demand is expected to grow for dimension stone during the next 5 to 10 years because of applications in residential markets, improved technology and variety, and the increased costs of alternate construction materials. In office building construction, growth is expected in the renovation markets. Current high commercial vacancy rates has increased competition in attracting and keeping tenants, causing some owners to upgrade appearance with stone."

HJB, in visiting with a large cross-section of dimension stone industry officials, found the above statements to be true. In fact, virtually all quarries visited and contacted are working at full capacity to fill orders. It was also learned that the demand for dimension stone has been increasing dramatically from 1997 to 1999. In addition, there is a shortage of good quality red and brown colored sandstone nationwide, for not only new construction, but for restoration projects.

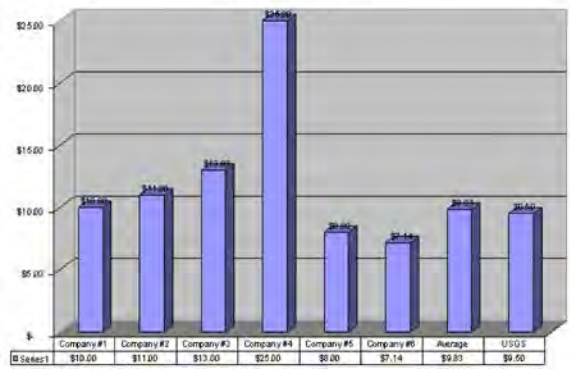
Dimension Stone Pricing

One of the most critical elements of this study was to determine if quarrying dimension stone in the Upper Peninsula would be cost effective, based on current prices in the market.

The average prices for granite, sandstone, and limestone throughout the country were obtained through correspondence with officials at the USGS. In addition to these numbers, confirmation of prices from individual companies was made.

Following these contacts, we have concluded that the development of a dimension stone industry in Michigan's Upper Peninsula would have an excellent chance for success if quarryable stone could be found. This is based on projected extraction costs versus prices paid in the marketplace. The cost of extracting dimension stone blocks normally can be done for less than half of the prices being paid in the market.

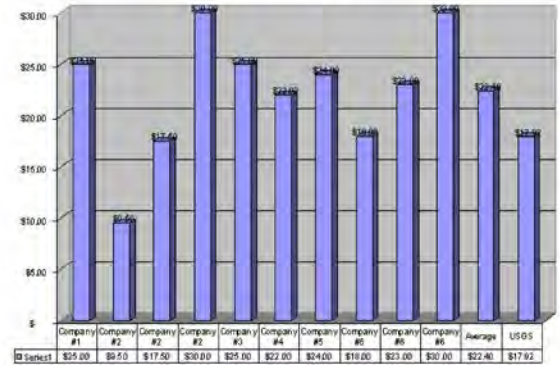
Using the Stone WoR1d 1998 Buyers Guide, which has a comprehensive directory of stone suppliers, fabricators, and installers, we contacted a cross-section of companies and requested price lists. Prices were given for tiles, slabs, flagging, monuments, and quarry blocks in many different types, colors, and textures of stone. In the interest of consistency, we used only the prices for granite, limestone, and sandstone quarry blocks.



Sandstone

Polling of selected sandstone quarry operators indicated an average price of $138 per ton. The USGS figures show an average of $128 per ton. Conversions were done based on the assumption that there are 14 cubic feet of sandstone per ton.

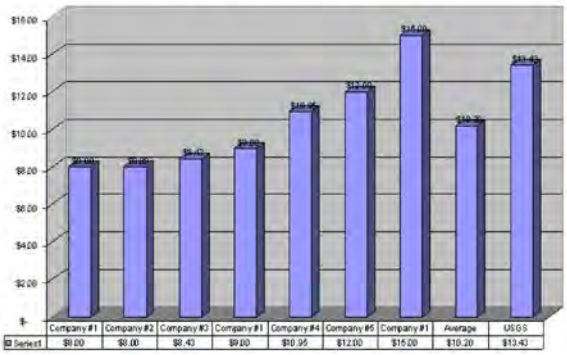
Figure 6. Sandstone Block Pricing Per Cubic Foot.



Granite

Polling selected companies showed an average price of $269 per ton. USGS poll averages $248 per ton. Prices for granite vary greatly depending on the quality, color, and scarcity. Conversions were made based on the assumption that there are 12 cubic feet of granite per ton.

Figure 7. Granite Block Pricing Per Cubic Foot.



Limestone

The average from the quarries polled is $143 per ton -- USGS average is $152 per ton. The overall average is approximately $150 per ton. Conversions were made based on the assumption that there are approximately 14 cubic feet of limestone per ton.

Figure 8. Limestone Block Pricing Per Cubic Foot.

The charts illustrate the values of dimension stone at quarries at various locations around the country. The average prices listed on the charts for each stone type were calculated independent of the prices obtained from USGS, who conducts an annual poll of nationwide dimension stone prices, fob quarries. The comparison of the prices compiled from polling by HJB and the USGS figures.

As shown by the bar graphs, there is considerable variance in the price quotes from each company, and there is even fluctuation in pricing within individual companies. These differences show the influence that the color and texture of a stone have on the market price. The more rare and exotic a stone, the higher the price it commands.

We have found that in the granite market, the "hot" colors are reds, blues, greens, and multicolored stones. Sandstone colors that are in demand are the darker browns and reds. These popular colors can bring prices double the price of a more neutral colored stone. Even though these are the sought after colors in the dimension stone market at this time, all natural stone is in high demand. The international dimension stone industry has grown dramatically in the past few years.

Stone Sites Investigated

The following list is a description of the 97 sites that were investigated by HJB. Each description indicates the county, stone type, and plat map location. From these sites we have selected the sites that offered the best potential for dimension stone quarry development. Detailed descriptions of these sites are shown following this list. See fold out map- "Sandstone Quarries and Hard Stone Sites in the Upper Peninsula" prepared by the Western Upper Peninsula Planning and Development Region.

Site # County
Description and information

1 Ontonagon County
Rhyolite Porphyry - pinkish orange groundmass with pink feldspar and grey quartz phenocrysts NW ¼, Section 20, T49N, R42W outcrops found on both sides of M64 info from MTU report

2 Ontonagon County
Rhyolite Porphyry - dark orange color SE ¼, Section 3, T49N, R41W site is adjacent to U.S. Forest Service Road #473, accessible from Bergland by county road (old M64) info from MTU report

3 Marquette County
Altered Peridotite - green, black, white, and purple colors NW ¼, Section 31, T48N, R27W belt of quarries found short distance north of US41 and town of Ishpeming info from MTU report

4 Marquette County
Granodiorite - pink with seams and patches of pale yellow (weathers to light tan and pinkish tan) SW ¼, Section 32, T49N, R25W found on County Highway SSO, five miles NW of Marquette city limits info from MTU report

5 Marquette County
Marble - tan, pink, purplish-pink, and hematite red SW ¼, Section 8, T47N, R2SW found at edge of A. Lindberg and Sons' sand and gravel operation info from MTU report

6 Alger County
Dolostone - color ranges in shades of blue grey to tan SE ¼, Section 24, T46N, R18W found in old quarry operated by A. Lindberg and Sons, off of M28 on Percy Road info from MTU Report

7a Alger County
Sandstone - red and tan colors Section 26, T47N, R21W Section 26, is inactive Brownstone Quarry info from MTU report

7b Alger County
Sandstone - red and tan colors NW ¼, Section 18, T47N, R21W Section 18 found off of USFS road 2484 (Alger Stone Company of Munising) info from MTU report

8 Marquette County
Granodiorite - grayish pink groundmass with pink feldspar phenocrysts NW ¼, SW ¼, Section 14, T48N, R26W found in a road cut on county highway 810 info from MTU report

9 Marquette County
Granite - pink to orange color NW ¼, SW ¼, Section 32, T47N, R26W found in road cut near M3S, 6 miles south of Palmer village limits info from MTU report

10 Baraga County
Sandstone - red and white colors Section 34, T52N, R33W found on quarry that is adjacent to US41 and Soo Line Railroad info from MTU report

11 Marquette County
Red Jaspilite - red and steel grey banded color NE ¼, Section 10, T47N, R27W found at Jasper Knob in Ishpeming info from MTU report

12 Marquette County
Granites- grey, med. grain, granite- 70% orthoclase and microcline, about 20% quartz and 10% plagioclase (AN15) NE ¼, SE ¼, Section 20, T46N, R25W Marquette County highway #533 found 3 miles to east info from MTU report

13 Marquette County
Granites - rusty pink, med. grain, granite - 50% perthitic microcline, 35 to 40% oligoclase and 10% quartz. NE ¼, SE ¼, Section 20, T46N, R25W Marquette County highway #533 found 3 miles to east info from MTU report

14 Marquette County
Granites- grey, fine grained quartz monzonite NE ¼, SE ¼, Section 20, T46N, R25W Marquette County highway #533 found 3 miles to east info from MTU report

15 Marquette County
Metadiabase - dark sage green SE ¼, Section 35, T48N, R27W found in railroad cut info from MTU report

16 Marquette County
Black Jaspilite - black with steel grey bands SE ¼, Section 10, T47N, R29W found near Humboldt Mine info from MTU report

17 Marquette County
Amphibolite - dark colors (black) NE ¼, NE ¼, Section 32, T47N, R29W continuations of outcrop found in NW ¼, NW ¼ Section 33 and SE ¼, SE ¼ of Section 29 found in road cut on Marquette county highway 601 info from MTU report

18 Marquette County
Granite Porphyry - grey groundmass with light pink phenocrysts NE ¼, Section 1, T46N, R30W found in outcrops along M95 info from MTU report

19 No Sample

20 Dickinson County
Tremolitic Marble - crystalline and white, pink, pale green and sometimes faintly blue, NE ¼ of the SE ¼ Section of 34, T42N, R30W found in newly developed rock cut in a prominent ridge of Randville dolomite info from MTU report

21 Dickinson County
Sandstone - colors range from buff to tannish yellow to orange, and brick red SW ¼, Section 30, T42N, R29W found at Groveland Mine area info from MTU report

22 Dickinson County
Amphibolite - very dark green color SW ¼, SE ¼, Section 30, T42N, R29W found not far from Groveland Mine hard surfaced road info from MTU report

23 Dickinson County
Pegmatite - pink to orange color NW ¼, SW ¼, Section 20, T42N, R29W outcrop found at point north of M69 which is 4.5 miles east of the junction of M69 andM95 info from MTU report

24 Dickinson County
Granite - pink color Sl/2 of Section 26, T42N, R28W found in dikes of Felch Quarry Co. info from MTU report

25 Dickinson County
Marble - mostly clean white color, some green, pink, greenish yellow, grey present Sl/2, Section 26, T42N, R28W found in Felch Quarry Company info from MTU report

26 Marquette County
Quartz Diorite - colors range from mottled green to tan, black, and white SE ¼, SE ¼, Section 30, T49N, R25W found in outcrops along Marquette County highway 550 info from MTU report

27 Marquette County
Quartz Diorite - pink color SE ¼, SE ¼, Section 4, T48N, R2SW adjacent to Marquette County Highway SSO and the railroad info from MTU report

28 Marquette County
Altered Gabbro - dark green with pink and light green patches SE ¼, NW ¼, Section 10, T48N, R2SW found ¼ mileW of County Highway SSO, ¼ mileS of Lake Superior and Ishpeming Railroad info from MTU report

29 Marquette County
Quartzite - off-white to grey, glassy color SE ¼, Section 36, T48N, R2SW info from MTU report

30 Marquette County
Marble - pink to purple and pinkish tan to brown in color SW ¼, NW ¼, Section 6, T47N, R24W found in outcrop that lies 40 feet west of US41 info from MTU report

31 Marquette County
Quartzite - white to faint green color found at outcrops as a prominent ridge on US41 at east city limits of Negaunee info from MTU report

32 Marquette County
Quartzite - dark grey and bluish grey color found at outcrops as a prominent ridge on US41 at east city limits of Negaunee info from MTU report

33 Houghton County
Felsite Conglomerate - tan and orange with some rust red, reddish brown, and reddish orange SE ¼, NE ¼, Section 8, T55N, R33W found in waste rock piles adjacent to shafts of inactive Boston mines info from MTU report

34 Baraga County
Altered Gabbro - black color NW ¼, Section 22, T48N, R31W found in road cut on US41 (other sites nearby) info from MTU report

35 Baraga County
Quartzite - tan, off-white, and very light grey Section 28, T5lN, R31W found in area adjacent to county road from Huron Bay to Arvon info from MTU report

36 Dickinson County
Sandstone - tan, buff, reddish-brown color (weathers to dark color) SW ¼, NW ¼, Section 4, T42N, R30W found in an outcrop adjacent to M95 info from MTU report

37 Dickinson County
Granite Gneiss - grey and white background with pink crystals SE ¼, Section 21, T42N, R30W found in outcrops that appear as low rounded knobs extending eastward from M95 info from MTU report

38 Dickinson County
Dolostone- mostly pink with some grey, tannish pink, and bluish grey colors NW ¼, NW ¼, Section 9, T39N, R29W found in quarry east of Strawberry Lake and on the north edge of village of Norway info from MTU report

39 Schoolcraft County
Dolostone - grey and various shades of tan NE ¼, SW ¼, Section 14, T42N, R16W found adjacent to M94, 7 miles north of Manistique in a quarry owned by the county info from MTU report

40 Delta County
Dolostone - blue grey to buff or tan in color NW ¼, SE ¼, Section 3, T40N, R19W found in a pit located immediately adjacent to US 2 info from MTU report

41 Delta County
Dolostone - white, blue-grey, tan and buff colors Section 24, T38N, R19W found at top of high cliffs on shore of Lake Michigan (Roen's Quarry) info from MTU report

42 Ontonagon County
Epidotized Basalt - pale green and greenish yellow SW ¼, Section 35, T5IN, R38W accessible from Mass-Adventure road info from MTU report

43 Ontonagon County
Altered Rhyolite - yellow green and olive green (may have bluish covering of copper carbonate) NE ¼, Section 6, T48N, R42W found in road metal quarry located on north side of M28, 1.2 miles west of its intersection with M64 at Bergland info from MTU report

44 Ontonagon County
Banded Rhyolite - pink to pinkish brown and orange NE ¼, Section 6, T48N, R42W found in road metal quarry located on north side of M28, 1.2 miles west of its interSection with M64 at Bergland info from MTU report

48 Ontonagon County
Amygdaloidal Basalt - dark purplish red with orange, red, white, and green spots SEI/4, Section IS and SWI/4, Section 14, T5ON, R39W found in rock piles of Minnesota Mine info from MTU report

46 Chippewa County
Beach Cobbles - Sections 3 and 4, T5ON, R7W found along shore of Lake Superior info from MTU report

47 Chippewa County
Dolostone - near white to tan and buff colors Section 23, T42N, RSE found in Somes Quarry info from MTU report

48 Hillsdale County
Sandstone - tan and dirty brown color found on a farm 3/4 mile NE of junction of Sand Lake Road and on Road, west of Hillsdale info from MTU report

49 Jackson County
Sandstone - yellow, tan, and buff colors Section 31, T3SN, R2E found on quarry of Star Stone Co. in town of Napoleon info from MTU report

50 Huron County
Limestone - Section 5, TI6N, R1OE Found in quarry operated by Wallace Stone Co. info from MTU report

51 Presque Isle County
Dolomitic Limestone found in quarry of Onaway Stone Co. located adjacent to M211 and 112 mile north of Onaway info from MTU report

52 Alger County
Sandstone - Location on Sand Point Section 19, T47N R18W Info from Gere

53 Alger County
Sandstone - Quarry located along shore east of Bay Furnace and west of east line of Section 28, T47N R19W Info from Gere

54 Alger County
Sandstone - Quarry located on Laughing Fish Point Section 25-26, T48N R22W Info from Gere and Eckert

55 Alger County
Sandstone - Quarry located "along the Laughing White Fish River below Laughing White Fish Lake" Section 34, T47N North to Section 26, T48N R22W Info from Gere

56 Alger County
Sandstone - Quarries located on Powell (Paul's) PointN.Y2, Section 27, T47N R19W Section 26, 27, T47N, R19W Info from Gere and Eckert

57 Alger County
Sandstone - Quarry located on southwest end of Grand Island Bay* SE ¼,Sl5,T47N,R19W Info from Eckert

58 Alger County
Sandstone - Rock River Brownstone Company SIS, T47N, R21W Info from Eckert

59 Baraga County
Sandstone - L'Anse Brownstone Company Quarry SW,Section 25, T51N R33W Info from Gere and Eckert

60 Baraga County
Sandstone - Superior Red Sandstone Company Quarry NE, Section 2, T52N R33W Info from Gere

61 Chippewa County
Sandstone - Quarry "located on Sugar Island near Churches Landing" NE, SE, Section 36, T48N R2 E Info from Gere

62 Houghton County
Sandstone - Michigan Redstone Company NE, Section 24, T53N R33W Info from Gere

63 Houghton County
Sandstone - Stone Quarry Lake NE, SW, Section 8, T53N R32W Info from Gere

64 Houghton County
Sandstone - Quarries (along Keweenaw Bay) Section 24 & 25, T53N R33W Info from Gere

65 Houghton County
Sandstone - Kerber-Jacobs Redstone Co. NE,Section 19, T53N R32W Info from Gere

66 Houghton County
Sandstone - Quarry located "at head of Portage Lake" probably somewhere from this point to Hancock and on the north or Hancock side of the Portage Ship Canal Section 31 or 32, T55N R33W Info from Gere

67 Houghton County
Sandstone - Wolf and Jacobs Company located at Portage Entry* "Lot 1" ofS19, T53N, R32W info from Eckert

68 Houghton County
Sandstone - Numerous quarries run by the Portage Entry Quarries Company Section l8, T53N, R32W Also Section l3, 18, 19 Info from Eckert

69 Houghton County
Sandstone - Quarry located on the Keweenaw Bay (Kerber-Jacobs Redstone Company) Section 8, T53N, R32W Info from Eckert

70 Houghton County
Sandstone - Quarry located two miles inland from Red Rock (Excelsior Red Stone Company) Section 8, T53N, R32W Info from Eckert

71 Houghton County
Sandstone - Quarry located near Portage Entry, adjoining government lighthouse reservation (Lake Superior Redstone Company) Lot3 Section 19 T53N R32W Info from Eckert

72 Houghton County
Sandstone - Quarry located just west of Lake Linden, Section 1, T55N, R33W called Torch Lake Quarry Lot3, Section 19 T53N R32W Info from Eckert

73 Keweenaw County
Sandstone - Quarry of Traverse Bay Redstone Co. NE ¼, NW ¼, NW ¼, Section 6, T56N R31W Info from Gere and Eckert

74 Keweenaw County
Sandstone - Quarry run by the Portage Entry Quarries Company Section 6, T56N, R31W Info from Eckert

78 Marquette County
Sandstone - Quarry (valley close to road), Section 23, T48N R25W Info from Gere

76 Marquette County
Sandstone - Quarry located slightly west of Lighthouse Point at Marquette Section 24, T48N R25W Info from Gere

77 Marquette County
Sandstone - South Marquette Section 26, T48N, R2SW Info from Eckert

78 Marquette County
Sandstone - Mount Mesnard Section 3S, T48N, R2SW Info from Eckert

79 Marquette County
Sandstone - Mouth of Salmon Trout River Section 30, T52N, R27W Info from Eckert

80 Marquette County
Sandstone - Thoney's Point Section 3S, T5ON, R26W Info from Eckert

81 Baraga County
Slate - Section 29, T51N, R31W Found north of L'Anse, near Slate River Old slate quarry All information from Kim Stoker.

82 Marquette County
Granite - SE ¼ Section 14 T47N R29W Found in road cut at first creek crossing, 2 miles south of Humboldt Mine on Route 601.

83 Marquette County
Granite - SW ¼ Section 22 T47N R29W Located 3.5 miles south of Humboldt Mine on Route 601 - at the first sharp curve.

84 Alger County
Red and white Sandstone - SE ¼ Section 8 T47N R21W Found on an outcropping on M28 and Shelter Bay Road, approx. 30 miles east of Marquette.

88 Delta County
Limestone - T41N R18Wor T40N R19W Found in quarry located right off of US2 near Isabella

86 Delta County
Limestone - Found in quarry located approx. 8 miles south of US2 near town of Ensign

87 Marquette County
Siliceous limestone - white color found north of Arnold

88 Schoolcraft County
Limestone - Inland Quarry, found off of US2 in Gulliver

89 Dickinson County
Sandstone - found in road cut along M69, near Felch

90 Dickinson County
Marble - Section 34,35 T42N R30W Found off of Herzog Road Old marble quarry site

91 Dickinson County
Marble - Section 34,35 T42N R30W Found off of Herzog Road Old marble quarry site

92 Dickinson County
Marble - Section 34,35 T42N R30W found off of Herzog Road Old marble quarry site

93 Dickinson County
Pegmatite - Section 23 T42N R30W Found near the river

94 Alger County
Sandstone -- reddish white color Section 11 T47N R20W On M28, in Christmas, turn north on Reindeer Road. Near the end of the road at 5-Mile Point, there is a road/trail that goes across Section 13 & 14. This road goes to the shoreline in Section 11.

95 Alger County
Sandstone - light purple/white color SW ¼ NE ¼ Section 29 T47N R21W Found near Old M28 and HO1

96 Marquette County
Syenite Porphyry - Section 17 T48NR26W Found near Negaunee on property of Negaunee Rod and Gun Club

97 Marquette County
Bell Creek Gneiss - NW ¼ Section 32 T47N R28W found south of the Greenwood Reservoir

Most Promising Sites

Of the 97 sites investigated, 11 locations were selected as having the best potential for development as dimension stone. Some of the locations had more than one site. See the map titled," Sandstone, Hard Stone and Limestone Quarry Sites in Upper Michigan," prepared by the Western Upper Peninsula Planning and Development Region. Below is more detailed information including field investigation notes. In some cases core drilling has been completed or is scheduled for the summer of 1999. These will be so noted.

A rating system was set up to determine which sites were the best candidates for quarry development. Four criteria were used in the rating: location, color, texture, and stone deposit. Each site was rated on a scale of 1 to 5, with 1 being a poor rating and 5 being a good rating.

Site	Location	Color	Texture	Stone Deposit	Total
1	3	2	3	1	9
3	4	4	4	3	15
7A	3	5	5	3	16
9	2	3	2	2	9
18C	4	5	5	4	18
23	3	3	1	4	11
62-71	1	5	5	3	14
72	2	4	5	5	16
91	2	2	I	3	8
96	3	4	4	4	15
97	4	4	4	3	15

Location: This is an evaluation of the accessibility of the site, the proximity to homes/businesses, and the availability of the site to existing infrastructure.

Color: This is an evaluation of the color of the stone based on current market trands and the potential this stone has to satisfy these market trends.

Texture: This is an evaluation of the texture of the stone and its applicability to popular uses of dimension stone (i.e. monuments).

Stone Deposit: This is an evaluation of how extensive the deposit is, how fractured it is believed to be, how consistent it is believed to be.

After completing the study it became apparent that certain areas of the Upper Peninsula had greater potential than others for development. The best potential for granite occurred in an area both north and south of Highway 41 and Highway 28, between Marquette and Champion. There were several excellent granite sites, showing good color in this area. Also, along Highway 95, south of Highway 41 and 28 there are many outcroppings of granite with favorable color. These are located both on the east and west sides of the highway, as far south as Iron Mountain. Another area to consider is the area from the towns of Ontonogan to Greenland to Wakefield.

Excellent sandstone deposits show up in the Jacobsville area, south of Lake Linden, along the west and east shore of Keweenaw Bay and the area along Highway M28 between Munising and Marquette. A secondary consideration for sandstone quarries would be in the Sault Ste. Marie area.

Site #1

Stone Type:	Rhyolite Porphyry
County:	Ontonogan County
Location:	NW ¼Section 20 T49N R42W USFS
Land Ownership:	Outcrops of this stone are found on both sides of M64, approximately 3 miles north of Bergland
Directions to Site:	
Description of Stone:	pinkish orange groundmass with pink feldspar and grey quartz phenocrysts.
Description of Site:	The outcropping is located on both sides of the Gogebic Hiking Trail in the Ottawa National Forest Land. All visible outcrops are on the road. There are no homes or buildings in the area. An old gravel pit is a half-mile north of the outcropping on the west side of M64. It appears there is a new gravel pit being developed on the east side of M64.
Core Drilling Status:	This site is scheduled for core drilling during the Spring/Summer of 1999

INFORMATION FROM MTU REPORT

Outcrops of this attractive stone occur on both sides of M64 in the NW ¼of Section 20, T49N, R42W. ¼

The rhyolite has a pinkish orange fine-grained groundmass in which are distributed larger crystals of pink feldspar and gray quartz.

Outcrops weather to light shades of pink, tan, and white. Strong and closely spaced joints trend N85°E and dip 67°S. This material could be quarried by the shelf method in the development stage but eventually would become a pit operation with attendant minor water problems. There is a possibility that some large blocks could be quarried but most of the product would be crushed stone for precast concrete panel surfacing.

Site #3

Stone Type:	Altered Peridotite
County:	Marquette County
Location:	NW ¼ Section 31 T48N R27W Cleveland Cliffs Iron Company
Land Ownership:	
Directions to Site:	This stone is located in the Peninsula Quarry. This area can be accessed by taking 573 to the northwest corner of Deer Lake and turning west onto Road GN. There is a fork in the road -- take

	the road on the right. There is a locked gate on this road, which is the entrance to the Ropes Mine. Continue through the mine to the Peninsula Quarry.
Description of Stone:	This stone is known in the industry as Verde Antique. The colors present are green, black, white, and purple.
Description of Site:	This site has a large cliff that appears to have a large deposit of the "Verde Antique" stone. It has been previously tested and drilled by other investigators. At the prime site, a large quantity has been blasted for fill or other purposes, which will make the job of opening up a face somewhat more expensive. There has been one deep core drill hole in the center of the deposit, which was done by the Ropes Gold Mine Company, which will give the investigator an idea of the depth and quality of the stone.
Core Drilling Status:	This site is scheduled for core drilling during the Spring/Summer of 1999.

INFORMATION FROM MTU REPORT

Several quarries are located in a belt of serpentine (altered Peridotite which occurs a short distance north of US41 and the town of Ishpeming. The samples examined came from the Peninsula Quarry location in the NW ¼of Section 31, T48N, R27W.

Material from this quarry and from several others has been marketed in the past, but these operations have not been financially successful although the stone is of good green, black, white, and purple colors and is said to compare favorably to the best Italian Verde Antique.

Most of the stone in the area examined is of some shade of green. Much of it has a brecciated appearance and veins and stockworks of fibrous green amphibole are common. White carbonate patches and veins are also common. There are great variations in textures and allover patterns.

Serpentine minerals, chlorite, carbonate, and actinolitic amphiboles are the common minerals. Pyrite, magnetite, and other opaques were noted. There are no traces of original ultramafic minerals or textures present.

On the basis of the inspection of only one quarry, it appears that blocks as much as six feet square could be selectively quarried. However, smaller blocks are most abundant.

With modern methods of quarrying and processing, it might be possible to market this Verde Antique. Waste from slabbing operations could be used as terrazzo stone.

The location of the serpentine (including Verde Antique) belt is shown on the geologic map of the Upper Peninsula published by the Michigan Geological Survey.

Site #7A

Stone Type:	Sandstone
County:	Alger County
Location:	Section 26 T47N R21W
Land Ownership:	Leonard Wilson or Brownstone Inn
Directions to Site:	This site is located opposite the lakeside of the road near the Brownstone Inn. There is a two-track road immediately west of the building.
Description of Stone:	This sandstone is a reddish brown color.
Description of Site:	This site is the location of the pre-existing Brownstone Quarry. The Lindberg Construction Company, when building the new M28, filled in the old quarry (around 1975). The quarry is estimated to be less than 100 yards off of M28. Currently there is a large clearing area, which would be a good place for test drilling.
Core Drilling Status:	This site is scheduled for core drilling during the Spring/Summer of 1999.

INFORMATION FROM MTU REPORT

There are extensive deposits but relatively few outcrops of Cambrian sandstone in the northern part of Alger County. More information concerning these sediments can be obtained from the 1958 report of W. H. Hamblin.

A quarry in Section 26, T47N, R21W, now known as the Brownstone Quarry, has supplied dimension stone in the past,

but is currently inactive. The Alger Stone Company of Munising has from time to time quarried stone from a site alongside U.S.F.S. road 2484 in the NW ¼of Section 18, T47N, R21W. Here the rock occurs in the upper part of the Cambrian Jacobsville and the usual red and light tan, medium- grained sandstone is exposed. Flat lying beds one to fourteen inches thick are present with thicker beds showing crossbedding. A major joint set trends N80°W. Mineralogically, the rock consists of about 75% quartz together with microcline, plagioclase, muscovite, hornblende, garnet, leucoxene, and lithic fragments of

chert, slate, basalt, and felsite. The sand grains are angular to subrounded. Both the white and red sandstones are very porous and poorly cemented. Cementing materials are quartz, sericite, and iron oxide with the latter absent in the light- colored sandstones.

Site #9

Stone Type:	Granite
County:	Marquette County
Location:	NW ¼Section 22 T46N R26W Tilden Mining Company
Land Ownership:	Timothy, Vivian, John Filippi
Directions to Site:	Outcrops of this stone are found on both sides of M35, approximately 6 miles south of Palmer, at the Fifteen Creek crossing.
Description of Stone:	This stone is a pink to orange colored granite.
Description of Site:	The material along the road is well shot and there are no large pieces to be seen. There are three separate outcroppings and one big cliff. The stone has quite a bit of quartz in it.
Core Drilling Status:	This site is not scheduled for core drilling at this time.

INFORMATION FROM MTU REPORT

Outcrops of this attractive stone occur on both sides of M64 in the NW ¼of Section 20 T49N R42W.

The rhyolite has a pinkish orange fine-grained groundmass in which are distributed larger crystals of pink feldspar and gray quartz.

Outcrops weather to light shades of pink, tan, and white. Strong and closely spaced joints trend N85°E and dip 67°S. This material could be quarried by the shelf method in the development stage but eventually would become a pit operation with attendant minor water problems. There is a possibility that some large blocks could be quarried but most of the product would be crushed stone for precast concrete panel surfacing.

Site #18C

Stone Type:	Granite Porphyry
County:	Marquette County
Location:	Section 23 T47N R29W
Land Ownership:	Escanaba Paper Company
Directions to Site:	Take Highway 601 to FP 601 East. Go in on this road about 1 mile and the stone is found on the west side of the road.
Description of Stone:	This stone is a pink colored granite with flecks of black.
Description of Site:	This site is a recent clear cut area. Several outcroppings are visible of a very consistent light red to pink stone on the surface. The interesting thing about this site is that the stone is quite contiguous - relatively free of fractures and color is consistent over a half mile area. This site shows the best promise for monument stone.

Core Drilling Status:	This site has been core drilled in December of 1998. See Appendix C for core drilling report.

Site #23

Stone Type:	Pegmatite
County:	Dickinson County
Location:	NW ¼SW ¼Section 20 T42N R29W Rev.
Land Ownership:	Will Blomquist / State of Michigan
Directions to Site:	An outcrop of this stone is found .3 miles east of Groveland Mine Road and M69
Description of Stone:	Pink to orange in color, some chips of mica present.
Description of Site:	The outcropping is more like 60 ft. high by 300 ft. wide vs. 80 ft. high by 400 ft. long as in the report. The south face of the outcropping has been shot off at some time. Once inch bore holes are exposed on the face. After further exploring, a climb to the top exposed a larger deposit running to the north. 300 ft. from the face is a new home, possibly a weekend get away or hunting camp.
Core Drilling Status:	This site is not scheduled for core drilling at this time.

INFORMATION FROM MTU REPORT

Pegmatite is prominently exposed in the NW ¼of the SW ¼of Section 20, T42N, R29W. The outcrop is only a short distance north of a point on M69, which is 4-112 miles east of the junction of M69 with M95. This is only one of a number of large pegmatites in the area.

This massive pink to orange pegmatite is exposed as a lens shaped knob rising nearly 80 feet above the general level. It crops out for a distance of about 400 feet in the east-west direction. The strikes of the enclosing metamorphic rocks are also east west. As a whole, the pegmatite shows little jointing, sheeting, or fracturing.

Microcline is the major mineral in the rock. It is both perthitic and poikilitic with albite as the second feldspar in both situations. Small amounts of quartz are present. Muscovite is also present and is the greatest drawback to extensive use of this pegmatite as terrazzo stone or precast concrete panel aggregates.

Sites #62-71

Stone Type:	Sandstone
County:	Houghton County
Location:	T53N R32W and T53N R33W Multiple
Land Ownership:	
Directions to Site:	These sites are all old quarry sites in and around the town of Jacobsville.
Description of Stone:	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
Description of Site:	Many of these sites are filled with water, and look like ponds.
Core Drilling Status:	This site is scheduled for core drilling during the Spring/Summer of 1999.

Site #72

Stone Type:	Sandstone
County:	Houghton County
Location:	Section 1 T55N R33W
Land Ownership:	Lake Superior Land Company
Directions to Site:	take First Street on South edge of town -- head WNW-- jog one block North over to road continuing WNW (17.9 miles). At C&HRR Grade Copper Range RR running NNE/SSW-- go SSW-- structures on left (south), posting with NO TRESPASSING sign-- continue uphill. (Al thought he was in Section!T56 R33). Continue WNW up hill. Overgrown grassy trail (road to left/south) continues up hill to West. Intersect old RR take sand trail road to WNW (uphill). Tanks and low rectangular grade (bearing 140°) and curving more southerly, 2-track trail bearing 240° and road you are on bearing 340°. Also a 2-track road bearing 280° to a roofed structure 150 yards on NW side. Walk to NW side along trail road around north edge -- come out by 9-ft. ledge with 2" drill holes (weathered) spread 12" apart.
Description of Stone:	This stone is reddish brown colored sandstone with a consistent fine-grained texture.
Description of Site:	Formally excellent quarry site - filled with water - however, excellent ridge running in a northerly direction NNE by SSW - plenty of land for exploration.
Core Drilling Status:	This site has been core drilled in December of 1999. See Appendix C for core drilling report.

Site #91

Stone Type:	Marble
County:	Dickinson County
Location:	Section 34 and Section 35 T42N R30W
Land Ownership:	multiple owners
Directions to Site:	Take the road directly across from the Randville Bar, approximately 3/10 of a mile-there is a road going to the left- blacktop- on this corner lives Don Hamby. At this corner, traveling 3/10 of a mile, northerly, we encountered the quarry, on the left-hand side. There were 6 or 8 large concrete pillars visible with past quarry activity to the north of these pillars.
Description of Stone:	This marble deposit is white in color.
Description of Site:	There were 6 or 8 large concrete pillars visible with past quarry activity to the north of these pillars.
Core Drilling Status:	This site is not scheduled for core drilling at this time.

Site #96

Stone Type:	Syenite Porphyry
County:	Marquette County
Location:	Section 17 T48N R26W
Land Ownership:	Escanaba Paper Company / Bishop Trust
Directions to Site:	This site is found North of Negaunee - take Baldwin Road North to Negaunee Rod and Gun Club (Club on left). Take the road to the East of Baldwin road approximately 1-1 ¼ mi.- go North across

	power line and ridge will be running east and west.
Description of Stone:	This is a large grained, pink and black colored stone.
Description of Site:	This site is most interesting in the fact that the stone contains no silica and is softer than most granites, which will make the stone easier to cut. On the surface it appears that there is a large deposit. The stone should have a good potential in the marketplace because of its unique characteristics and color.
Core Drilling Status:	Preliminary drilling completed, needs further investigation.

Site #97

Stone Type:	Bell Creek Gneiss
County:	Marquette County
Location:	SE ¼Section 29 T47N R28W
Land Ownership:	Cleveland Cliffs Iron Company
Directions to Site:	This site is located south of the Greenwood Reservoir off of Highway 478.
Description of Stone:	The stone samples collected are a very bright red with quartz phenocrysts dispersed throughout.
Description of Site:	This site is virtually on Highway 478, just south of the Greenwood Reservoir. This is a very interesting site as the stone is quite contiguous and easily accessible. There are fractures present which only core drilling will determine how deep they are.
Core Drilling Status:	This site has been core drilled in December of 1998. See Appendix C for core drilling report.

Sites# 18C, 72, and 97 have been core drilled. Site #96, which was scheduled for drilling in December 1998, was inaccessible at the time of year that drilling was to be conducted. This site will need to be revisited and core drilled at another time. Sites #1, 3, 7A, and the Jacobsville area (#62-71), along with a site selected in the Sault Ste. Marie area are scheduled to be core drilled in the summer of 1999. For additional information on the results of this drilling see Appendix C.

Equipment Recommendations

Prior to two years ago, limited information was available from resource people in the Upper Peninsula on how to extract dimension stone. HJB initially investigated all historic documents to determine the previously used methods of extracting, which in many cases were similar to those methods used today. Interestingly enough, channeling machines were in use prior to the turn of the century as well as the use of drilling, plugging, and feathering methods to extract blocks of sandstone. Even rudimentary wire saws were in use.

HJB attended many conferences, meetings, and trade shows and spoke with many equipment suppliers, both from North America and abroad (mostly from Italy and Germany). The two trade shows attended were Coverings '98 in OR1ando, Florida, at the end of April, and the StonExpo '98 in New OR1eans, Louisiana, at the end of October. These shows are annual events and feature hundreds of exhibitors from all aspects of the stone industry.

HJB also visited many major quarries throughout the U.S. and has viewed firsthand different methods of extraction. Granted, there are many ways of extracting dimension stone, and below are listed examples from HJB of typical equipment that will produce the best yield of dimension stone.

Traditionally, in order to remove granite from a quarry face, extensive drilling and blasting methods were used. This method has the potential of fracturing the deposit as a result of the blasting. This reduces the yield of stone blocks that can be quarried. A method that is being used extensively throughout Europe, and increasingly more frequently in the U.S., is the wire saw method. By using a wire saw, the need for large scale drilling and blasting is eliminated and

the number of workers needed in the operation is less. The wire saw is used basically by drilling a vertical hole and a horizontal hole that intersect. The diamond wire is then threaded through the holes and the wire is attached to a wire saw. As the stone is cut, the machine moves backward on a track. This system is very self-sufficient and has a high yield.

Figure 9. Typical Wire Saw.

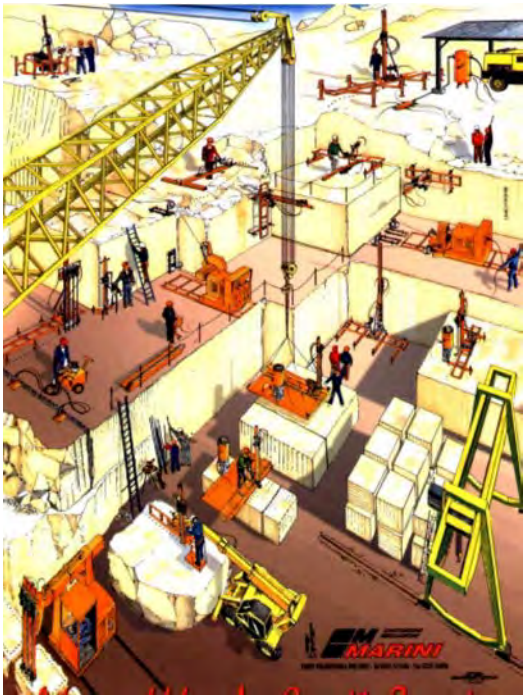


Figure 10. Illustration of a granite quarry operation, using wire saws, drills, and other support equipment for extraction.

Below is listed the basic equipment needed to start a granite dimension stone quarry. HJB recommends using the most modern methods, including the use of wire saws. There will always be a need for a certain amount of drilling, blasting, and channeling to optimize yield in any quarry. It is understood that many traditional granite quarry operators still use the tried and true methods of drilling and blasting for block extraction, using close-hole extraction methods.

There are a number of major manufacturers of dimension stone quarry equipment that HJB have been in contact with, who have offered their services to develop the most optimum equipment in developing a quarry. This will include not only the experienced quarry person, but also the novice. These dealers will provide cost estimates for the smallest quarry operation to the largest. In Appendix D, are the names of several of these companies that can be contacted.

The following prices have been obtained primarily from Marini Quarries Group. It must be noted that the equipment and the prices are provided as an example of the types of equipment that a typical granite quarry would require. Pricing can vary greatly depending on whether or not one buys new or used equipment, leases equipment, and also when and where the equipment is bought. See Appendix G for Marini's complete granite quarry plant.

Typical Equipment Needed for Granite Quarry:

TYPE OF EQUIPMENT	PRICE
Drilling Equipment	
Pneumatic block-cutter for vertical and horizontal cutting	$6700
Pneumatic silenced rock drill (X 2) Extension Track (3 meters) Platform for block cutter	$7000
Pneumatic block-cutter with piston feeding for horizontal drilling	$1100
Pneumatic rock drill	$1950
	$4000 $1900

Cutting Equipment	
Diamond Wire Sawing machine	$33,160
Pneumatic perforator to execute holes	$9700
Down-the-hole-hammer (3")	$2800
Button bit for granite	$670
Drilling rods	$175
Accessories and Consumables (estimated 6 months)	$64,000
Air compressor and hoses	
Diamond wires	
Integral drill steel (various diameters)	
Grinding machine for integral drill steels	
Hydraulic pushing machine	
Other miscellaneous	
Accessories-- Spare Parts (estimated 2 years)	$10,500
Electric generator	$20,000
SUBTOTAL	$163,655
Optional Equipment	
Derrick Crane (25 Tons)	$104,800
Dust eliminator ("Hydro-Jet")	$450
Hydraulic Press for sleeve bushing extracting	$1150
Device for cutting at 90° complete with column	$2000
Device for rubber replacing	$500
Center square for drilling rods	$170
Set of various quarry tools	$1300
Quarry truck with 25/30 ton capacity (used)	$20,000
Front end wheel loader (with forks) size 988B CAT	$90,000 - $100,000
SUBTOTAL	$356,370
TOTAL	$520,025

Sandstone quarry equipment is similar to granite extraction equipment in many ways. One of the major differences is the use of diamond belt saws rather than wire saws for block cutting. The belt saw looks very much like a giant chainsaw, is water- lubricated, and is very quiet. An example of a belt saw in operation is shown on the following page. W. F. Meyers Company, out of Bedford, Indiana, is the manufacturer of the diamond belt saw. Like the granite equipment prices, the prices given for the sandstone quarrying equipment have been gathered from many different sources and is to be used as an example of the typical equipment needed in a quarry of this type. Prices can vary depending on the specific needs of a particular developer and a particular quarry site.

Figure 11. Mansfield Stone Inc., Brazil, Indiana. Small scale sandstone quarry.

Figure 12. Mansfield Stone Inc., Brazil, Indiana. Diamond belt saw used for sandstone block extraction.

Typical Equipment Needed for Sandstone Quarry:

TYPE OF EQUIPMENT	PRICE
Water Pumps (min. 2 in.)	$600 each
Power Units - portable - 155-210 KW- 3306 Cat Engine	$30,000-75,000 used
Stone Handling Equipment	
Rubber tired crane - 20-30 ton	$30, 000- 60,000 used
Front end wheel loader (with forks) size- 988B Cat	$60,000- 120,000 used
Drilling Equipment	
Hand Drills	$2000 each
Air Drill	$35,000 new
Quarry Pickup truck (4X4)	$20,000 used
Miscellaneous Tools	$5000
Lifting Cables and Straps	$2500
High Pressure Washer	$1000
Back hoe (235 Cat)	$80,000- 120,000 used
Dozer (D7-D8 Cat)	$40,000- 120,000 used
Power Cable - hose lines (water and air)	$6000- 10,000
10 Ft. Belt Saw with spare parts	$100,000 new
600-750 Air Compressor	$30,000 used
Truck Scale	$50,000 new
In Line Weight Scale	$3,000
On Board Loader Scale System (988B Wheel Loader)	$8,000
TOTAL	$503,100 - $762,100

As with the list of granite equipment, the prices accompanying the equipment are estimates based on prices that we have received from various equipment manufacturers. These prices are shown to give an example of the equipment costs for opening a quarry. There are many factors affecting the prices that will have to be dealt with on an individual quarry basis.

Transportation Costs

Transportation is a major cost in any industrial stone quarrying venture. It is not quite as critical in dimension stone because of the high average value per ton. For example, sandstone sells on an average of approximately $135/ton, granite averaging approximately $230/ton, and limestone averaging approximately $150/ton.

Stone from the Upper Peninsula can be transferred in many ways, but the most cost-effective method is via truck. Trucking costs within a 400-mile radius will average $30 - $40/ton, delivered. This will encompass the major markets of Cleveland, Detroit, Milwaukee, Chicago, and Minneapolis.

As a comparison, stone can be shipped via water, if markets can be developed to distant ports, overseas, or on the East Coast. At the turn of the century, dimension sandstone in blocks typically 4' x 4' x 8' in size were transported via small boats, schooners, and barges. This could occur via freighter much cheaper than trucking. As an example, products shipped via Great Lakes freighter from Marquette to Detroit or Chicago will average $7 - $10/ton. This price is for traditional crushed aggregate. This price will increase because of the extra labor and time involved in loading large blocks.

A point to be considered, is the potential for breakage of the stone during the increased handling. As an example, stone would be picked up at the quarry and loaded on a truck. From there, it would be transported to a port, such as Lake Linden, Houghton, or Marquette. At this point, it would be transferred to the ground for reloading to the ship. At its final destination, it would be unloaded from the ship and reloaded onto a truck, for transport to the factory for processing. The total cost involved in transporting via boat for short hauls could easily far exceed trucking charges. The exception to this could be block stone hauled from the Upper Peninsula to European ports such as England, Germany, Italy, and Greece for reprocessing and value added.

Other modes of transportation, including rail, were investigated. This could be cost- effective for those quarries located very near existing and operating rail lines. Wisconsin Central Railroad is the predominant carrier in the Upper Peninsula and there are some economies of scale of shipping via rail, if the end user is also near the rail line. Rail costs per ton, for example, from Marquette to communities in Illinois, Wisconsin, and Minnesota, could range as low as $12/ton to a high of $20/ton. Experience indicates the most cost-effective method of moving dimension stone blocks is via truck - it saves money overall - and reduces potential for contamination and breakage.

HJB Recommendations and Conclusions

Following a full year long examination of the dimension stone potential in the Upper Peninsula of Michigan, H. James Bourque & associates, provides the following recommendations and conclusions.

Dimension stone development has an excellent potential for success in the Upper Peninsula for certain types of stone.

Sandstone

Sandstone, which was quarried extensively at the turn of the century, is a virtually untapped resource. Massive sandstone deposits stretch from Sault Ste. Marie to Duluth. Of particular interest and meriting closer examination, is the corridor from Munising to Marquette and Baraga to Jacobsville, as well as the east side of Keweenaw Bay, north of L'Anse.

We would highly recommend further exploration of the deposits around Lake Linden and in the area of Jacobsville. This area originally was not scheduled for further exploration because of the many cottages and year-round homes that exist in this area. It has recently become apparent that there may be a potential for developing a small sandstone quarry without disturbing either the environment or the homeowners. Several sandstone quarry operators in other states, as well as local investors, have shown sandstone development interest in this area.

Another area that has produced relatively good sandstone in the past is located in the corridor between Marquette and Munising.

The sandstone deposits are massive along the south shore of Lake Superior. There is the potential for developing several sandstone quarries. The developing of three to five quarries in various locations is realistic.

One of the major concerns that the sandstone quarriers around the turn of the century had was the quality of stone. Of the thirty plus quarries that started, less than one half of them had quality stone. The caution here is that all stone is not the same, especially with sandstone. As deposits are selected, it is vitally important that the stone be tested for strength and chemistry. The stone must pass a rigorous testing procedure to be approved. The American Society for Testing and Materials (ASTM) has a set of standards for all types of dimension stone. Some of these tests would include absorption, bulk specific gravity, and compressive strength.

Another major concern with the developers of sandstone in the past was the amount of overburden (unusable stone and soil) covering the sandstone. Some very good deposits were left because of the increasing depth of the overburden, making it cost prohibitive to continue to produce. Some of these sites still have potential because of the increased value of sandstone in modern times. Also, with more modern equipment it is less costly to remove overburden.

Granite

Granite deposits are extensive, however, as shown in the text of this report, the most favorable granite deposits are in a rather localized area, situated in the corridor west of Marquette and Ishpeming, including the north side of Highways 28 and 41, and on the east and west side of Highway 95, going south to Iron Mountain. The best deposits are found in this area, and predominately near the Humboldt Mine, which is located near the intersection of Highways 95, 28 and 41. There are other deposits in other locations of the Upper Peninsula in lesser concentrations.

Two granite deposits have been drilled in the fall of 1998. The most promising being Site #18C, which has an extensive red granite deposit. (See notes in the core drilling log in Appendix C.) The stone quantity is deep; however, fractures near the surface of the two holes that were drilled were numerous. Experienced dimension stone quarry operators indicate this is not unusual and more drilling should be conducted. In many cases, ten to twenty holes are necessary to prove out a deposit.

The granite sites that were examined, for the most part, showed excellent colors and potentially could produce good quantities of stone. However, most of the granite deposits appeared to be very fractured on the surface with the exception of the several that had been indicated for further evaluation. If additional core drilling continues to show good color and minimal fractures, at least two or three quarries can be developed for granite. If the results prove positive, we are confident that new investors, as well as established dimension stone quarry operators, will be interested in developing quarries and in buying stone.

During the past eight months, most of the major operators have been monitoring our progress in our study. Ten different companies have shown an excellent interest - some for sandstone, others for granite. Three of them represent some of the largest dimension stone companies in the nation.

Limestone

Limestone deposits are also extensive and have been mined commercially for many years for industrial stone usage. However, only one small quarry has extracted stone for building purposes.

There are many limestone quarries in southern Indiana and elsewhere that produced great quantities annually. However, this stone is much softer than the limestone and dolomites found in the Upper Peninsula. There are several limestone quarries of the same formation operating in northern and central Wisconsin. Two of the major quarry operators have shown interest in examining the limestone deposits located along the Lake Michigan shoreline. In addition, contacts have been made with current industrial limestone quarries and they have indicated their willingness to allow dimension stone developers to examine the stone on their property, to determine if it will make dimension stone.

The Market Place

Interest has been generated throughout the dimension stone industry in the Upper Peninsula dimension stone study. It has been determined that profitable sandstone quarries can be developed- the stone is here, and of good quality.

The granite deposits are extensive with good color. It is questionable as to whether it can be extracted in blocks that will produce a good yield. This is still a major question with the limited drilling program that has taken place. It is now up to the private sector to continue to do this examination to determine for themselves if the granite will provide the yield to become cost effective.

Limestone also represents one of the greatest resources, however, it has not been extracted for commercial dimension stone. The stone is much harder than found elsewhere in the country, making it more costly to produce. With advanced technology, the cost effectiveness of developing the limestone deposits of the Upper Peninsula could well be realized.

From the onset of this study, it was apparent that if quality stone could be found, it could be competitive in the market place. In the text of this study, the average prices paid for granite in blocks at the quarry average in excess of $215/ton for granite, limestone at $188/ton, and sandstone at $133/ton. Using even the most basic extraction methods will produce a profit when the stone sells in the amounts indicated.

Of interest is the average size of a dimension stone quarry. Most readers are familiar with large-scale mining operations

for iron, copper, and traditional aggregates where the mines and quarries are very extensive, covering in some cases, many miles. Dimension stone quarries, on the other hand, normally are quite small and cover only a few acres. Even some of the largest companies, such as Cold Springs Granite, are using relatively small acreage in their quarry operations. However, many quarry to great depth and use either ramps or derricks to remove stone.

The other concern and point of consideration by many is the noise and dust factor connected with traditional quarries. HJB toured a cross-section of quarries around the country and most are able to control noise and dust. However, there are still some quarries using traditional methods of extracting using close hole drilling, blasting, and channeling that cause dusty and noisy conditions. Quarries using the state of the art methods that have been developed by the Europeans are relatively dust and noise free. Those quarries that use belt saws and wire saws were virtually noise free. Water is used to lubricate the belt or wire saws, eliminating most of the dust. In fact, in several instances, while touring quarries, people could stand within six feet of an operating saw and it was quiet enough to carry on a conversation.

Drilling and channeling to open up stone faces is still needed in the quarry. The blasting that occurs is usually less frequent and very low power charges. Also, two people can move many of these drills; they are very portable.

The above point is made to indicate that even some small areas can be developed for dimension stone quarries. Many times, good sites are discarded because of proximity to development, such as housing.

Equipment and Cost of Production

One of the most important needs in extracting dimension stone is selecting the best equipment for the job. At the beginning of the study, contact was made with major manufacturers of quarry equipment and it was found that most of the state-of-the-art equipment was developed in Europe, mainly in Italy and Germany. Contact was made both in Europe and with representatives in the United States with equipment suppliers. Each of the major manufacturers and suppliers are able to develop equipment needed for any sized quarry, including a start-up operation. An example of this is shown in the text of the study.

Average cost for equipment to begin a quarry operation will run between $300,000 and $500,000. To illustrate the type of assistance the manufacturer will provide in developing equipment needs, we have copied a quote from Marini Quarries Group, a major manufacturer in Italy, showing a complete granite quarry plant (Appendix G). Several other companies will provide the same service. Among those are:

Pellegrini - Italy

Marini Quarries Group - Italy

Bergman Blair Machine Co. -New York, U.S.

Addresses and contacts for these companies are shown in Appendix D.

These companies will not only develop the most optimum equipment for any sized quarry, but their representatives will personally visit the site and provide an evaluation of the best way to develop the quarry. Also, once the equipment is purchased, they will send a representative to assist the quarry personnel in learning how to run each piece of equipment. Also, if desired, each of these companies have the ability to contract an experienced quarry manager to come to the United States who will work under contract, to help in the start-up phase of any new quarry.

Quarry Plan

Operating costs, by necessity, will be developed on a quarry-by-quarry basis. Two major factors will come into consideration: the first is the value of the extracted stone -this will vary greatly, depending on the type and color. The second is the cost of production, which will vary greatly, depending on the yield. The typical quarry traditionally yields approximately 25%-30% usable stone. Occasionally, stone of a lesser yield can be profitable if it is a rare or highly desirable color. Most small quarries will operate with no more than five to ten people, with most personnel having skills in several related areas.

Appendix F is a checklist to develop for a typical quarry.

Appendices

APPENDIX A - Summary of Quarry Operations in the Upper Peninsula

(Information from Dr. Kathryn Bishop Eckert's report, The Sandstone Architecture of the Lake Superior Region, 1982, pp. 41-66.)

Alger County

The Jacobsville formation extends in a three-to-four-mile wide belt along the south shore of Lake Superior from L'Anse to Munising. In Alger County at the points where the Laughing Whitefish and Rock Rivers empty into Lake Superior and break through the cuesta, one company briefly quarried a dark brown and variegated sandstone in the 1870's, and two, in the 1890's. EaR1ier, in the 1860's, builders of iron blast furnaces opened quarries on Grand Island and on Grand Island Bay.

At Powell's Point on Grand Island Bay (S27, T47N, R19W) and on the southwest end of Grand Island (SE ¼, SI5, T47N, R19W) the Schoolcraft Iron Company and the Bay Furnace Company opened quarries in the 1860's. These furnished a fair quality of light bluish red sandstone, sometimes mottled with lighter and darker colored specks, for constructing nearby iron blast furnaces.

65 Much later, in the 1920's, stone from another site at Powell's Point (S26,27, T47N, R19W) was used to build the Lincoln School and the Sacred Heart Convent in Munising.

In 1870 George Craig of Marquette and Henry D. Smith, a Marquette lawyer, who owned property near the mouth of the Laughing Whitefish River (S25,26, T48N, R22W) twenty miles east of Marquette, employed George P. Cummings, a civil engineer and land surveyor of Marquette, to investigate the suitability of the site for extracting stone.

66 Cummings identified outcrops, ledges, and rides with little soul cover near the mouth of the river and on a bay or arm of Lake Superior, where he thought a safe harbor could be constructed cheaply and easily. He described the stone as of "even better quality than that being shipped all the way from Bayfield, Wisconsin, to Milwaukee."

67 With this report, in February 1871, Craig and George Wagner, an explorer and mineralogist of Marquette, secured from Chicago investors financing for developing their quarry.

68 That spring the company built near Laughing Whitefish Point a settlement called Rockport, constructed a thirty-foot dock, sent to Bayfield for experienced quarrymen, and opened a quarry within 150 feet of the dock, from which it extracted what some anticipated would be a very marketable stone. It opened a second quarry about one mile inland and connected it to the dock by means of a plank tramway, over which horse-drawn cars transported the stone down a gentle incline to the landing.

The Marquette Mining Journal predicted a far-reaching market not only for the fine- grained stone from the newly opened Craig and Wagner quarry at Laughing Whitefish Point but also for brownstone from Lake Superior quarries everywhere. It thought this stone would supersede marble for "aristocratic city fronts" and "fashionable residences" in all the lake cities

69 The newspaper expressed romantically its optimism over the economic benefits of exploiting this natural resource.

The demand for it its unlimited; and these same stones sleeping so many years in obscurity, clambered over by the Indians and furnishing the hiding places for the wolf and bear, are now to be torn from their beds, transported and hewn into tasteful shapes, to be again sent forth in time, to almost every city south and west of Pittsburgh, and who knows, since the Orient and Occident have met, but that the products of this Boreal quarry may yet reflect the sun which lights the Inca or Aztec! And who knows, but the opening of these quarrys may mark an epoch, in the history and to a large extent affect the wealth of Lake Superior!

70 Early indications that the rock was of the best quality, fine grained, and "sufficiently hard to take a fine polish" proved false.

71 The rock did not hold out in uniformly good quality and too much worthless material had to be handled. By September 1871 the company suspended operations at a loss.

72 More than fifteen years later, in 1889, ChaR1es Johnston of Marquette, the principal investor in the newly incorporated rock River Brownstone Company, explored the company's property at Rock River (SI4,15,22,23 T48N R21W), three miles west of Au Train and twenty-five miles east of Marquette.

73 Drill core samples indicated the extent of a deposit containing a body of top grade, purplish brown sandstone,

another solid body resembling the "Marquette raindrop" sandstone, a layer of clear white sandstone, and a layer of brown and white variegated sandstone.

74 But the removal of the first large blocks more fully demonstrated to outsiders the value of the property.

The capping layer is a variegated stone good for foundations and rubble and immediately under this is a three foot layer of solid brown, free from all defects and possessing as rich a color as any stone on the market today. Below this is a deposit of clear white sandstone, something never before found on the peninsula. This stone has a very fine grain, is as solid and dense as the other varieties and is bound to full a ling felt want with builders as it will make a very handsome trimming for the clear brown, far surpassing in beauty any other stone yet used for that purpose. Already the architects have heard of it and a Milwaukee firm is waiting for the first block to be taken from the quarry to test it.

Below these layers are other layers of clear brown.... There is every indication the company has struck the richest kind of a thing in the stone business.

75 In one year's time, between July 1890 and at the next summer, workmen cleared and stripped a site, one-half mile in length by fifty-to-one-hundred rods in width, and built a dock, railroad siding, houses, and a mill.

76 The local newspaper predicted that the Rock River Brownstone Company would become one of the largest and best paying quarries in the Lake Superior region and would contribute to the prosperity of the area. As soon as the Rock River Brownstone Company placed its sandstone on the market the Marquette Mining Journal attributed its success to the ingenuity of Marquette men: "The Rock River Brownstone Company is a Marquette institution, organized, managed and chiefly owned by Marquette men and its success is the success of the industries tributary to this city.

77 The year 1890-91 was one of great productivity for the Rock River Brownstone Company. It secured four large contracts, three of them for local projects, and one for a project in Bay City. It supplied brownstone for the Alger County Jail at Au Train; the footing, rubble, and sawed stone for the Marquette County Savings Bank; "pure and dazzling "white sandstone for the Odd Fellows and Knights of Pythais Block in Marquette; and brownstone for the Masonic Temple in Bay City.

This success inspired the Marquette incorporators of the Rock River Brownstone Company to establish the Butler Brownstone Company in 1891. They purchased from the Rock River Brownstone Company a 130-acre site immediately north of that company's quarry and opened a quarry within a year.

79 There is little information on the production for subsequent years. Both companies at Rock River surely suffered from the economic depression of 1893, the gradual disfavor of brownstone, and the difficulty of maintaining a shipping dock on Lake Superior. By the mid-1890s the Butler Brownstone Company probably had closed and the Rock River Brownstone Company slowed down greatly. Both the Butler Brownstone Company and the Rock River Brownstone Company were listed in the Michigan State Gazetteer and business Directory for 1893. Neither was listed in 1895-96. Through 1906 the Rock River Brownstone Company listed an office in Marquette from which it probably sold the stone it had on hand. 80

Marquette County

Between 1869 and 1900 more than a dozen companies intermittently extracted sandstone from quarries in Marquette County. The principal quarries were located at two sites south of the center of Marquette where patches of Jacobsville sandstone are exposed: at South Marquette (S26, T48N, R25W), and at Mount Mesnard (S35, T48N, R25W). Two other quarries were opened where the Jacobsville formation crops out along Lake Superior: at the mouth of the Salmon Trout River (S30, T52N, R27W), six miles northwest of Marquette; and at Thoney's Point (S35, T50N, R26W), three-quarters of a mile north of the Little GaR1ick River and thirteen miles northwest of Marquette.

CaR1 Rominger investigated the sandstones of Marquette while conducting a geological survey of the eastern portion of the Upper Peninsula in 1871-73. He described the quarry site in a sandstone patch at Marquette as follows:

The Potsdam deposits seem to have formed a continuous belt all around the Huron mountain district, which must have been an island in the ancient ocean. But a part of these deposits has been washed away again, and only in protected situations have patches of the rocks resisted destruction in places where the denuding forces had freely acted. One of these patches, surrounded by Diorite and Slate hills, we find within the city limits of Marquette, in a small side valley, at the lake front of which the Marquette gas works and an iron furnace have been erected.

From the quarries opened in this recess where the stratification is more regular than usual, quarrymen obtained "an admirable fine building material."

82 At South Marquette in Section 26, companies formed and operated by Chicago, Detroit, and Marquette investors, several of whom were cut-stone contractors and dealers and had been trained as stone workers in Ohio and Germany, extracted stone. Eventually most of the firms restructured and consolidated into one, which, under the supervision of

John Henry Jacobs, became the major quarry company at Marquette. Jacobs invested in, developed, and managed several companies, all top producers.

83 In 1869 Peter Wolf (1819-1902), a German-born, cut stone contractor in Chicago, acquired from George Craig a portion of the property known as the J. P. Pendill Farm on Section 26 in the southern portion of Marquette, a short distance from the lakeshore.

84 At this site a quarry had been partially opened some years eaR1ier, and from it stone taken for the construction of Marquette's eaR1iest and "most substantial business blocks"--in fact, the only buildings in town that survived the fire of 1868-- and for the construction of the Marquette and Ontonagon Railroad shops. The Marquette Mining Journal for 28 May 1870 projected, "There is upon this land a large bed of excellent red sandstone, which needs only to be properly developed to demonstrate its immense value." Subsequent newspaper articles expressed the belief that the quality of this stone surpassed that used extensively in "the fashionable quarters of New York City," and surpassed "any known deposits in the country." Moreover, the bed of "fine grained, compact sandstone, brown, clear and free from streaks or blemishes" was reportedly inexhaustible.

85 The Wolf firm was the first to work the Marquette quarry in a "proper and legitimate way," using plugs and feathers to trench and underseam any size stone in a form nearly as perfect as that obtained with the saw and chisel. The eaR1ier method of extracting stone by blasting with powder frequently checked, shattered, and damaged stone. Wolf and Son shipped by 1869 most of its large fine blocks of uniformly dark brown, moderately coarse-grained sandstone to Chicago. It sold cheaply the rubble for local use in cellar walls and foundations and supplied for home consumption pieces of coarser-grained, less uniformly colored sandstone.

86 Wolf employed as his foreman John Henry Jacobs, who eventually played a principal role in the development of the sandstone industry in the Lake Superior region.

People expected the development of the South Marquette quarry by Wolf and Son to contribute greatly to the growth of business and commerce in Marquette. The local newspaper said, "In addition to furnishing the bulk of the iron product of the United States, we shall in a few years supply the best building material for all the Great Lakes cities."

87 Recognizing the economic value of the sandstone at this location, George Craig had purchased the Pendill Farm in the late 1860's. In April 1869 he sold the parcel already opened to Wolf and Son; in June 1872 he sold the remaining parcel to a group of Marquette men who established the Marquette Brownstone Company, opened a quarry, eventually acquired the Wolf and Son Company, and promoted the use of sandstone locally.

88 The principal stock holders of the Marquette Brownstone Company were Peter White, Samuel P. Ely, William Burt, Frederick Wetmore, Sidney Adams, and Henry R. Mather, all frequent collaborators in local and regional business ventures.

89 Jacobs had a moderate interest and Alfred Green, a local builder, had a small interest. Two experts in Upper Peninsula geology, Thomas B. Brooks of the economic division of the state geological survey of the Upper Peninsula, and Raphael Pupelly, who taught mining engineering at Harvard and who had served as state geologist of Michigan from 1869 to 1871, held small interests, probably given to them by primary investors to lend scientific credibility to the venture, and thereby, to encourage the investment of others.

90 Under the supervision of Jacobs, the Marquette Brownstone Company continued to work the quarry opened by Wolf, and expanded it to the adjacent site. In the mid-

1870's in a flurry of activity the company erected a stone sawmill and a substantial shipping pier. The company furnished stone locally for St. Paul's Episcopal Church, the Superior Block, another business block, and the Marquette High School. Certainly White, a vestryman at St. Paul's and the other major stockholders, all prominent Marquette citizens, influenced the choice of sandstone for the church and school. White and Mather selected it for their own building, the Superior Block, built by Alfred Green who held a minor interest in the company. In 1878 the company leased its operation to Edward M. Watson and E. B. Palmer, a local firm that supplied goods, supplies, and materials to lumberman, furnace men, and townsmen. Jacobs continued to superintend the operation until 1881.

On property adjoining the Marquette Brownstone Company's quarries members of the Burt family of Detroit and Marquette opened a quarry in October 1872, after forming the Burt Freestone Company. The Burt Freestone Company erected a sawmill and installed machinery to cut the stone into windowsills, water tables, columns, and caps. These it sold, along with blocks and ashlar in brown, variegated, and mottled colors. Although the deposit resembled that of the Marquette Brownstone Company, the stone was lighter in color and inferior in quality. The company was less successful than others and ceased operations by 1879.

The Burt family long had engaged in identifying and promoting the mineral resources of the Upper Peninsula. John and William Burt had assisted their father, William Austin Burt (1792-1858) in a ten-year-long land survey of the Upper Peninsula, conducted in coordination with Houghton's geological survey. John Burt (1814-1886) employed the

knowledge and skill gained in conducting the land survey in assisting the development of the mineral resources of the Upper Peninsula through the promotion of the Lake Superior Iron Company, the canal at Sault Ste. Marie, and several iron manufacturing companies. He served as president of the Burt Freestone Company. William Burt (1825-1892) speculated in land, iron mining and manufacturing, invested in Marquette businesses, and managed the Marquette and Pacific Rolling Mills. John Burt's son, Hiram A. Burt (1839-1921), manager of several iron companies and investor in real estate, joined in the family company. Two of William Burt's sons, A Judson Burt and William A. Burt (1851-1893), cashier of the HuR1ey Bank at HuR1ey, Wisconsin, also participated. Like the Marquette Brownstone Company, the Burt Freestone Company promoted the local use of brownstone. As a member of the Baptist Church, William Burt probably influenced the decision of its building committee to use variegated brownstone for its Gothic Revival structure in 1884. And Hiram Burt chose smooth-cut hexagonal blocks of variegated brownstone for his elegant French Mansard style house on Ridge Street in 1872-76.

91 in the early 1880's, the Burt family leased the quarry to Jacobs, who paid royalties for the stone his company extracted.

In 1883 Jacobs interested Peter Wolf and Son in forming Wolf, Jacobs and Company to operate and to open more extensively the Burt Freestone quarry, then regarded by some as exhausted. The company built a mill to dress for market stone from both its Marquette quarries and a quarry that it had opened by then at Portage Entry on property leased from the Lake Superior Brown Stone Company. By 1887 Wolf sold out his interest in the company, and it became Furst, Jacobs and Company. The involvement of the Furst family of Chicago in the company provided additional capital needed for machinery, equipment, real estate, and expansion.

92 Then the company expanded, working quarries formerly operated by the Marquette Brownstone Company and Burt Freestone Company, and in 1891, opened new ones on land it acquired in the First Ward. That year Jacobs sold his interest in Furst, Jacobs and Company. By 1890 Furst, Jacobs and Company showed substantial profits. It divided $100,000 in cash dividends among six equal partners. It paid $500,000 in expenses, $60,000 in wages, $129,290 in freight, and $31,181 in royalties. Its assets included accounts receivable of $133,000, machinery worth $75,000, Marquette real estate valued at $30,000, and capital investments of $180,000.

93 Less successful was the quarry at Mount Mesnard in Section 35. Here, three miles east of Marquette, on 160 acres of land situated on the south slope of Mount Mesnard near the Marquette prison and the mouth of the Carp River and owned by the Michigan Land and Iron Company, a group of Detroit and Marquette investors developed a quarry discovered the year before by Myron E., Orrin, and MarkJ. David of Marquette. Test pits and drill core samples taken by George P. Cummings indicated that the deposit was made up of solid, clear brown, fine-grained sandstone that was situated in a bed only ten feet below the surface. With this information ChaR1es H. Little, a manufacturer and dealer in building supplies in Detroit, assembled a group of Detroit investors that included John H. Bissel, a lawyer who acquired a major interest, and Willard S. Pope, and engineer and bridge builder. Alfred Kidder, Boston-born agent of the Champion Mine, and the David brothers, all of Marquette, held minor interests.

94 The company had ambitious plans to operate the quarry on a large scale, employing the latest in machinery, steam derricks, steam drills, and channeling machines. The company quarried and shipped over 100,000 cubic feet of stone in 1891. But in 1893, then known as the Detroit Brownstone Company, it ceased operations, leased the quarry to others, and sold its equipment.

95 A contemporary professional opinion forecast the eventual demise of the Detroit Brownstone Company. Henry G. Rothwell, civil and mechanical engineer, clamed that the experience of this company illustrated how money could be lost in quarrying and how men ignorant of the business could induce others to invest in a losing proposition. The sandstone at this quarry on the Carp River over laid a quartzite formation and was very thin. Although the stone was a pleasing brown color, it was blotched throughout with white spots of hard quartz silica and alumina. The stone in this valley lies on the primary rock at an angle to the horizon of thirty degrees. This produces a strain and caused it to fracture in irregular prisms, almost immediately on being quarried. Rothwell claimed that a careful examination of he property and preliminary work would have revealed the lack of merchantable stone. Instead, at great expense, before the quarry was proven, the company built railroads, purchase and installed machinery, and erected shops, boardinghouses, stables and other buildings. It suffered an enormous, unnecessary loss.

96 The Newport and Lake Superior Brownstone Company made the major attempt to quarry brownstone west of Marquette on the shores of Lake Superior. At the mouth of the Salmon Trout River (S30, T52N, R27W), six miles northwest of Marquette, it opened a quarry in 1888. John H. Gillett (1843-1904), a Marquette lumber dealer and operator of a tugboat business, purchased 270 acres from the Newport and Lake Superior Land Company, and with Richard Blake, also of Marquette, stripped the over burden and opened a quarry.

97 The Marquette Mining Journal for 9 April 1887 proclaimed, "It will be a Marquette enterprise and all business connected to it will draw to Marquette." Indeed, Marquette investors developed the quarry, Marquette contractors stripped the overburden, Marquette laborers quarried the stone, and Marquette vessels shipped the stone.

The location of the site along the face of the bluff where clear sandstone jutted into the lake reduced the work required to open the quarry. Dirt removed in stripping the overburden was tossed over the edge of the bluff into the water, stone removed in stripping the overburden was used to riprap the dock. From this dock stone was shipped easily by scows to docks at Marquette. Under the supervision of Robert Wagner, the company erected a large blacksmith shop, store, boardinghouse, sleeping shanty, stable, and other structures. The bed yielded brown sandstone similar to that taken in Marquette, but varying considerable from layer to layer. All was reportably marketable, however. In fact, John Lawrence, Marquette's leading stone mason of the time, testified that it equaled the stone used in St. Paul's Episcopal Church (Gordon W. Lloyd, 1874-76). Despite Gillett's early success in securing in May 1889 an order for 25,000 cubic feet of brownstone for the First Presbyterian Church in Detroit, the Newport and Lake Superior Brownstone Company did not profit and endure.

Keweenaw Bay

L'anse and Portage Entry (Baraga, Houghton, and Keweeaw counties, Michigan

The profitable extraction of sandstone in the Keweenaw Bay area occurred where the Jacobsville formation crops out on the shores of the bay. This outcropping extends in a belt from Pequaming southwest down the east shore of Keweenaw Bay to L'Anse, around the head of the bay to Baraga, and northeast up the west shore of the bay to a point on the Keweenaw Peninsula several miles north of the entry to the Portage River. The rock on the east shore is a hard sandstone of a duller purplish brown than Marquette brownstone, that on the west shore is fine to medium grained and a deep rich brick red.

99 At least twenty companies owned or leased sites and operated quarries intermittently in the two major locations at L'Anse and Portage Entry and at several scattered locations in Keweenaw, Houghton, and Baraga counties between 1875 and 1918. Production peaked during the late 1880's and early 1890's when the Portage Entry Quarries Company, which operated its largest quarries on the west bay, probably became the largest producer of sandstone in the Lake Superior region. Production declined in the early 1900s and ended by WoR1d War One.

The L'Anse Brownstone Company opened the first sandstone quarry in the Keweenaw Bay area near L'Anse in the 1870's. it produced a small amount of stone for three years before the bank foreclosed on its mortgage. The quarry was revived briefly in the 1890s.

In 1875, Timothy T. Hurley of Marquette prospected for marketable sandstone, purchased from Peter Crebassa land on the east shore of Keweenaw Bay, one and three-fourths miles northeast of L'Anse, and organized the L'Anse Brownstone Company.

100 The sandstone at this site (S25, T51N, R33W) possessed a rich dark purplish brown color, sometimes banded with pale greenish gray spots, an even texture, and great hardness and strength. The bed was nine feet thick at the point where quarrying began. It extended back from the waterfront some four or five thousand feet and was covered with a drift less than two feet thick. The bayside location enabled the L'Anse Brownstone Company to handle its stone more easily and cheaply than others with beds so far from navigable waters that teams of horses had to haul the product to the shore. A rubble stone crib dock was built into sixteen feet of water, a depth reached less than two hundred feet from the shore. Rubble stone cribs just north of the quarry served as a breakwater and enabled ships to land in all kinds of weather. Large blocks of stone could be broken loose from the quarry, swung from the beds by a steam-powered derrick, lifted on tramcars, and carried without steam or horse power down an inclined tram road that ran the full length of the dock to ship's side. Another steam-powered derrick hoisted the stone from the docks onto the ships.

First managed by E. M. Wood, an Ohio quarryman and former employee of the Burt Freestone Company, and later managed by George Craig, the L'Anse Brownstone Company shipped no more than 10,000 cubic feet per year during the 1870's, despite management's predictions that it would produce ten times that amount and claims that it would collect on promises for orders sixty times that amount.

101 The L'Anse Brownstone Company went bankrupt in 1879. It was sold for $5,000 to the highest bidder, the St. Clair brothers of Ishpeming, investors in mining property.

102 In 1893 Chicago men revived on a small scale this quarry company and produced 2,000 cubic feet in 1894, 23,000 in 1895, and 21,000 in 1896.

103 During each period of operation, the L'Anse quarry furnished stone for local buildings. The First Methodist and Catholic churches in L'Anse of the 1870's and 1890's are examples.

At Portage Entry, fourteen miles east of Houghton, companies opened quarries which became famous and proved lucrative to their owners and operators. In fact the twelve-foot bed of sandstone located here was said to make of the Portage Entry quarries "yield like gold mines."

104 Recognizing the superb quality of the sandstone here and the facility for its shipment by water, speculators acquired titles and leases to land on the northeast side of the entry as early as 1870. At this point the stone crops out horizontally in a bluff which rises from the bay and is readily accessible for removal to ships. But quarry operations did not begin here untill883. Around them grow the settlements of Portage Entry, Craig, Jacobsville, and Red Rock. Two of the largest companies consolidated in 1893 and gradually took charge of some of the smaller ones as well. The largest producers of sandstone in this area were the companies associated with John Henry Jacobs from 1883 to 1902: the Wolf and Jacobs Company and its successors, the Furst and Jacobs Company, and the Furst, Neu and Company; the Portage Entry Quarries Company, a consolidation of the Furst, Neu, and Company and the Portage Entry Red Stone Company; and the Kerber-Jacobs Redstone Company.

Wolf and Jacobs Company opened the first quarry at Portage Entry in 1883 on the twelve-foot-deep sheet of sandstone discovered by Jacobs and Craig more than ten years before and noted by Foster and Whitney more than thirty years before. The Company leased from the Lake Superior Brownstone Company a site described as Lot one of Section nineteen (T53N R32W).

105 At this site the clear red stone was considered "unsurpassed" in quality for building purposes and "inexhaustible" in quantity. Even the laminated red and white stone was thought suitable for trimmings and ornamentation. The Marquette Mining Journal described the sandstone of Lot one as follows:

The thick layer of uniform merchantable stone, of beautiful color and fine texture, rises out of the lake at the western boundary of the property, and runs a quarter of a mile east where it thins out abruptly and becomes worthless. At the western limit overlying the clear stone is ten feet of tiny laminated stone, much of which is very beautifully variegated and striped, clear white alternating with clear brown.

106 Chicago men invested in the company, reorganized as Furst, Jacobs and Company in 1887. Jacobs supervised the work at the quarry during the years of greatest production and expansion, eventually selling out his interest in 1891. Then the company reorganized as Furst, Neu and Company. Jacobs received $100,000 for his one-sixth interest in Furst, Jacobs and Company. The Marguette Mining Journal for 6

June 1891 observed that with "no money but lots of grit" and "by hard and intelligent work" the firm of Wolf, Jacobs and Company "began to be known in the woR1d," was succeeded by Furst, Jacobs and Company and assumed "enormous proportions." From its early production of 90,000 cubic feet of stone in 1885, the company effected technological improvements so that production consistently exceeded 300,000 cubic feet annually between 1887 and 1891. Its peak was 480,000 cubic feet in 1890.

In 1893 Furst, Neu and Company and the Portage Entry Red Stone Company consolidated as the Portage Entry Quarries Company, with capital stock that totaled $1 million.

107 The firm placed J.W. Wyckoff, a Marquette man experienced in construction work, in charge and opened an additional quarry on Section 18 (TS3N, R32W). Wyckoff continued to manage locally the consolidated Portage Entry Quarries Company until it ceased operations around 1909. The quarry on Lot one of Section nineteen produced a total of 2,537,688 cubic feet of top grade and variegated stone between 1883 and 1898. Production consistently exceeded 300,000 cubic feet each year for the period 1887 to 1891, but peaked at about 480,000 cubic feet in 1890. The quarries on Section eighteen produced 487,029 cubic feet of stone between 1893 and 1898, averaging 81,171 cubic feet per year.

108 Over time the Portage Entry Quarries Company ran a large business, operating quarries on sections thirteen, eighteen and nineteen, and on land leased from the Traverse Bay Redstone Company (S6, T56N, R31W). As Wyckoff explained, the Portage Entry Quarries Company was to commercial red stone what the Calumet and Hecla Mining Company was to copper.

109 The Portage Entry Quarries Company operated according to sound business practices anywhere. The management of the company in Chicago, the agent in Marquette, and the superintendent of the quarry at Portage Entry corresponded daily. They discussed stripping new beds; shipping arrangements, including locating scows capable of transporting stone to various ports, the cost of freight, and negotiation with railroad companies; marketing the stone through the Chicago or Marquette office and by bidding on jobs locally; improving or constructing docks and the costs involved; moving stone from one agent or yard to another to full orders; wages and expenses; keeping good workers; maintaining machinery and equipment; renewing contracts and arranging visits; and cutting stone at the sawmill in Marquette.

110 On a 424-acre site (S8, T53N, R32W) on Keweenaw Bay, one mile north of Portage Entry, John H. Jacobs made plans to develop a quarry in October 1892, after selling out his interest in Furst, Jacobs and Company and organizing the Kerber-Jacobs Redstone Company. But first, he conducted drilling tests over a year-long period to determine the quality and extent of the sandstone bed. He assembled a group of investors, which included a Chicago man named Kerber, probably the son of Henry Kerber, the Chicago cut-stone contractor and partner of Henry Furst from 1861 to

1865 and the Marquette contractors, Powell and Mitchell.

111 Powell and Mitchell employed seventy men to strip the overburden of the Kerber- Jacobs site and construct a shipping dock on the unprotected shore of Keweenaw Bay. They opened the quarry one hundred feet from the edge of a fifty-two-foot bluff which forms the shore of the lake at that place. They cut and graded a road from the opening to the lake in direct line with the dock and on it laid a track over which steam-powered dump cars hauled stone. Parallel to the shore they put in a bulkhead of cribs made from heavy hemlock logs and filled with riprap discarded when stripping the quarry opening. They constructed a dock that extended into the lake 1,000 feet. Along the broad avenue leading from the quarry to the dock grew the settlement of Red Rock. The company's structures stood nearest the quarry. Higher up the hill some workers built hewn log houses side by side. W. J. Fales, superintendent of the quarry, oversaw the construction of two large boardinghouses, a blacksmith shop, barn, storehouses, and offices. The local newspaper said that "Redrock is already a very handsome little village" and noted the huge scale and full development of the Kerber-Jacobs quarry.

The Kerber-Jacobs company is starting out on a scale never before approached here, its equipment being perfect in every feature. It will spring into the field full armed both in quarrying and shipping facilities and as it is believed to have the thickest solid bed of stone ever tackled in this part of the country its operations are already attracting attention and it promises to be a large shipper this year. 112 By 1895 Kerber-Jacobs shipped 137,529 cubic feet of stone and in 1896, 125,000 cubic feet. It was then the second largest producer in the Keweenaw Bay area. 113 Its success was attributable to the rich bed of stone, the business and technical skill of its president, solid financial backing, and its Finnish workers. ¼ But by 1895 the sandstone industry at Portage Entry experienced the first tremors of its decline.

The several smaller companies formed in the 1890's met with more limited success, in part because by 1895 the industry was faltering. In April 1891 James H. Seager of Hancock and men from Detroit and from Racine, Wisconsin, formed the Excelsior Red Stone Company to quarry stone on a site (S8, T53N, R32W) two miles inland from Red Rock. Seager managed the quarry locally. F. L. Smith managed the general offices in Detroit.115 Locating the "true sheet" of stone took one year of systematic exploration. The marketable strata averaged eight feet in thickness, but twenty-one feet of material needed to be removed to reach it. The Excelsior Redstone Company transported its sandstone over three miles of railroad to Red Rock, then shipped it from the docks of the Kerber-Jacobs Company. In 1894 it shipped 18,000 cubic feet and in 1895, 45,000 cubic feet. Because it was unable to sell the stone in had in stock, it produced nothing in 1896 and ceased operations.116 In 1889 a group of Marquette men organized the Building Stone and Mineral Exploring Company to explore for sandstone on land near Portage Entry. Satisfied with the results of its testing, a group of nearly the same men formed the Lake Superior Redstone Company with a capital stock of $2 million. It acquired from the Building Stone and Mineral Exploring Company the lease of fifty-five acres (Lot 3, Sl9, T53N, R32W) adjoining the government lighthouse reservation and the Furst and Jacobs quarry. As the Marquette Mining Journal explained, "Now-a-days sandstone quarries are not opened up in a happy-go-lucky manner." Drill samples demonstrated that "the splendid sheet of No.1 stone on which the Furst-Jacobs and Malone Companies are now working" extended upon it an in greater density than existed on the latter's properties when quarrying first had commenced. 117 J. W. Wyckoff, then superintendent of the Furst-Jacobs quarry, took charge of explorations for the Building Stone and Mineral Exploring company and presented the following report:

The boring done shows conclusively that the sheet of stone which is now being quarried by Furst, Jacobs & Co. and the Portage Red Sandstone company undeR1ies the entire Building Stone & Mineral Exploring company's tract, the greater portion of which, as is the case with the two properties mentioned, is a No.2 quality. I succeeded, however, in locating a belt of No. 1 stone, beginning at a point 480 feet west of the northeast corner of said tract, this belt runs southeast by south, and cores taken out for a distance of about 900 feet at intervals of from 100 to 150 feet, the width of said belt being about 200 feet. It was my intention to continue testing the belt entirely across the property, as far as it extended, but as the drill had to go elsewhere I was not able to complete the work I had mapped out. I have no doubt, however, but that the belt of No. 1 stone extends nearly if not quite across the tract. ...

Comparing this No. 1 belt of stone with that which Furst, Jacobs & Co. are working, and its value becomes more apparent, the total of which was 1, 100 feet long, 225 feet wide with an average thickness of about 7 feet, giving 1,692,500 cubic feet of No. 1 stone, of only 252,000 feet in favor of the famous Furst, Jacobs & Co. quarry. Should the Building Stone & Mineral Exploring Co.'s belt prove to be 1,400 feet long it would give a total of 1,680,000 feet of No. 1 stone. Comment is not necessary. 118 Lot three was sited so as to permit the construction of a short dock, well protected from winds, and it contained a stand of timber for its construction. On this property a break in the terrain saved about eighteen feet of stripping, Only one or two feet of earth covered the first layer of stone. The twelve-foot sheet of top grade stone on which the Furst-Jacobs and Malone companies were working was covered here by various layers of stone, much of it merchantable, to a depth of about fifteen feet.

By summer Powel and Mitchell had uncovered a spare 108 feet by 188 feet, installed machinery, and constructed a dock. 119 The Marquette Mining Journal for 1 August 1891 note that No mistake has been made in opening the new

quarry and every dollar has been wisely expended. It will make a better record in this its first season than either of the old quarries did in their first year and the experience gained in handling he stone in the older openings will be of constant value in the working of the new. The stone is there in the quantity and quality which have made the Portage quarries famous and the fortune is there also for the stockholders just as it was in the other two.

Inland, in Houghton and Keweenaw counties, several quarries extracted stone for local use. Two were the Torch Lake Quarry and the Traverse Bay Red Stone Company. By 1880 the Calumet and Hecla Mining Company, then undergoing a period of great growth and expansion both at its copper mine location in Red Jacket and at its stamping mills at Lake Linden, took red sandstone from a site known as the Torch Lake Quarry (S1 T88N R33W) on a sandstone ridge just west of Lake Linden and near its railroad line between Red Jacket and Lake Linden. It used the company railroad between the mine and the stamping mill to transport the stone which was employed in some of its industrial buildings at Calumet and South Lake Linden.120 In 1894-98 ChaR1es Hebard of Pequaming formed the Traverse Bay Red Stone Company to quarry a pink-to-reddish-colored stone with white mottling on a 120- acre parcel of land (56 T86N R31W) at the head quarters of the Trap Rock River north of Lake Linden in Keweenaw County. Hebard laid eight miles of railroad track from the quarry west to land he owned to Keweenaw Bay, where he built a one-hundred- foot dock. He developed and equipped the quarry and shipped 6,800 cubic feet of stone in 1898. In 1896 20,000 cubic feet of stone were extracted; it then closed.121 Listed in the ledger for the Traverse Bay Quarry, later operated under lease by the Portage Entry Quarries Company and under lease from the ChaR1es Hebard estate, is the evidence that the Hebard site supplied rubble and sawed stone to local mining companies, builders, suppliers, and projects. It furnished rubblestone for the Baltic, Ahmeek, Allouez, Champion, Centennial, Mohawk, and Trimountain mining companies and to such local builders as Paul Roehm, Edward Ulseth, and Peter Donahue. 122

APPENDIX B - Stone Samples for Selected Sites

Site #1 Rhyolite Porphyry

Site #3 Verde Antique

Site #9 Granite

Site #18C Granite Porphyry

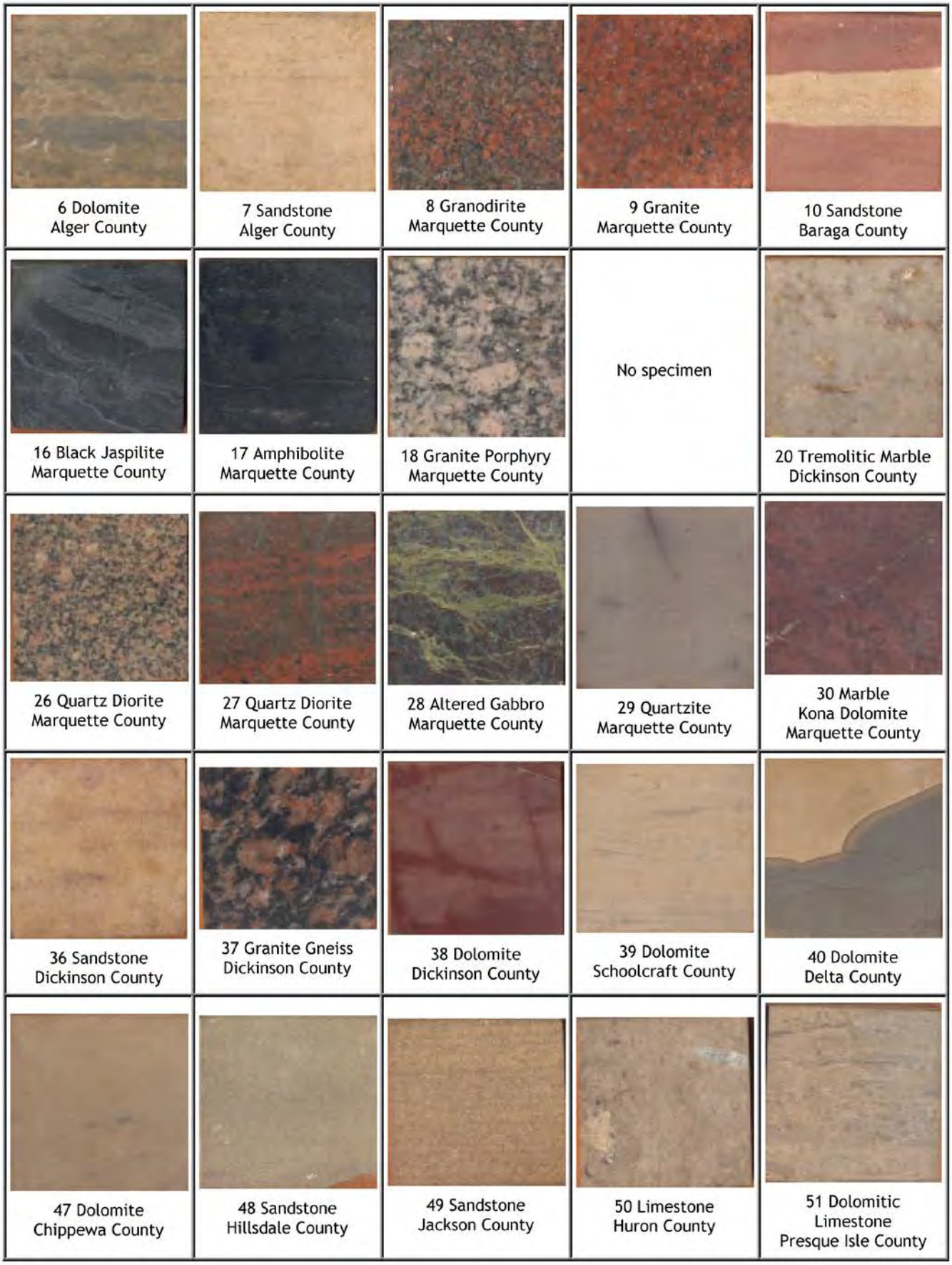
Site #96 Syenite Porphyry

Site #97 Bell Creek Gneiss

Red and White Variegated Sandstone

Uniform Red Sandstone

Samples from the site listed below - this and the next illustration are meant to be viewed side-by-side.



Samples from the site listed below - this and the previous illustration are meant to be viewed side-by-side.

APPENDIX C - Core Drilling Reports

The following pages are the core logs for seven sites that have been core drilled.

The drilling was done in two stages. The first stage of drilling occurred in December

1998 and sites 18C, 97 (BCG), and 72 (which is the Lake Linden sandstone site) were drilled. The second stage of drilling occurred in July 1999; sites 96 (referred to as Drill Holes# 3-1 and 3-2), 7A (referred to as Drill Holes #7-1 and 7-2), a site in the Jacobsville area (Drill Holes #66-1 and 66-2), and a site in Sault Ste. Marie (Drill Hole #1-1) were drilled at this time. Minerals Processing Corporation analyzed the cores from the sites 18C and 97, while Michigan Technological University students along with Dr. Allan Johnson analyzed the remainder of the sites.

APPENDIX D - The Following Companies Can be Contacted to

Develop Equipment Lists and Operating Costs:

Bergman-Blair Machine Corporation
Bergman, John
Job Title: President
12 North Cove Plaza
Oyster Bay, New York 11771
Bus: (516) 922-5353
Bus Fax: (516) 922-3256
E-mail: bblairmach@aol.com

Domenico Brocato Industries
Brocato, Domenico
Job Title: Vice President
8151-103 River Birch Drive
ChaR1otte, NC 28210
Bus: (704) 363-3999
Bus Fax: (704) 552-7366

Marini Quarries Group
ZeR1ia, CaR1o
Job Title: Sales Director
Via Beura, 44
28844 Villadossola, VB Italy Bus:390324575106
BusFax:39032454096

Pellegrini Precision Stonecraft, Inc.
2033 Castleway Lane
Atlanta, Georgia 30345
Bus: (404) 634-8040
Bus Fax: (404) 634-2266

The following companies can also assist in developing equipment needs. Park Industries is a major producer of quarrying equipment and can be most helpful to any quarry developer. W.F. Meyers, Inc. of Bedford, Indiana is the major manufacturer of belt saws for use in sandstone. Each of these will test the stone from any quarry and build the most optimum cutting devises to extract or fabricate.

Park Industries
Schlough, Thomas
Job Title: President
P.O. Box 188
St. Cloud, MN 56302
Bus: (800) 328-2309
Bus 2: (320) 251-5077
Bus Fax: (320) 251-8126
E-mail: park@parkind.com
Web Page: http://www.parkind.com

W.F. Meyers Company. Inc.
Dunlap, Dick
Job Title: Sales Engineer
P.O. Box426
Bedford, IN 47421-0426
Bus: (800) 457-4055
Bus Fax: (812) 275-4488

APPENDIX E - Quarrying Equipment for Granite

(The following photos are from the Pellegrini web page (http://www.stonecraft.net/) and are included in this report as examples of typical quarrying equipment.)

EQUIPMENT FOR THE EXECUTION OF THE FIRST OPENING CUTS

SLIM DRILLER

EQUIPMENT FOR THE CUTTING AND SIZING OF THE BENCHES

TBC 90/2 (LEFT)

TELEDEISEL TDD 100 (BELOW)

EQUIPMENT FOR SIZING BENCHES INTO BLOCKS

SLIM BAR

JACKING EQUIPMENT FOR TILTING OF BENCHES

CUSCINI

DRESSING EQUIPMENT FOR BLOCKS

DIAMANTFIL

HANDLING AND HOISTING EQUIPMENT

GRUDERRICK

APPENDIX F - Quarry Start-Up Checklist

The following are a number of items to be considered in developing a quarry in the Upper Peninsula. This information is meant primarily for an investor, new to the dimension stone business. The following questions should be considered when planning a quarry and developing operating costs.

IS THE COLOR OF THE STONE MARKETABLE?

Some colors will not sell. Dimension stone markets are always changing in regard to "hot" colors and textures.

IS THERE ENOUGH QUANTITY OF STONE TO SUSTAIN A QUARRY FOR AT LEAST 10 YEARS?

It will take at least 10 years to service debt and initial investments. HOW MUCH YIELD CAN BE EXPECTED EACH YEAR FOR THE FIRST 10 YEARS?

This is a calculated guess, even for the most experienced quarry operator. Much of the guessing can be alleviated by carefully examining the geology of the site and by executing a carefully planned core-drilling program. Bulk sampling and other test drilling will provide the developer with helpful information. A good number to shoot for is 25-40% yield. Depending on the market demands at the time, a smaller yield may still be profitable. Lower yields diminish the potential for profitability.

HOW ACCESSIBLE IS THE QUARRY TO EXISTING ROADS?

Building and maintaining roads into and out of the quarry can be an expensive process. Keep in mind that the road usage will probably only be a few truckloads of stone per week. Also bear in mind the type of weather that is present in the Upper Peninsula.

WILL THE QUARRY MAKE ENOUGH PROFIT IN THE FEW MONTHS PER YEAR THAT IT WILL BE OPERATIONAL?

The U.P. has severe winters and dimension stone quarries will only be able to extract stone in the months without snow (May- October).

HOW ACCESSIBLE IS WATER TO THE QUARRY?

Dimension stone quarrying equipment requires large amounts of water for lubrication and dust control. Ponds, lakes, etc. need to be in close proximity.

HOW WILL THE ELECTRICAL NEEDS OF THE QUARRY BE MET?

Most quarries will use gas-powered generators to supply power for equipment and other electrical needs. If the quarry happens to be near power lines, this would be the most economical method. If gas-powered generators are used, fuel storage must be close at hand.

WHAT TYPES OF EXTRACTION EQUIPMENT WILL BEST SUIT THE QUARRY?

In the text of this report we have shown the optimal equipment for a start-up operation. The costs of this equipment could be as low as $300,000 to $500,000. We recommend wire saws for granite and belt saws for sandstone. The manufacturers will evaluate any stone deposits and will recommend the most optimal equipment for extraction. If budgets are limited, used equipment is available, however, it is not recommended to buy used wire saws or belt saws.

WHAT NEEDS TO BE DONE TO PREPARE THE QUARRY FACE FOR BLOCK REMOVAL?

Most quarries have some amount of overburden of varying depths that must be removed. Excessive amounts can be very costly and will cut into the profits. This should be evaluated before deciding on the final quarry site. A carefully planned core-drilling program will determine the area with the least overburden and will also indicate the depth of the stone deposit. It is important to know how much overburden you will encounter in years following the opening of the quarry. Careful evaluation of this in the beginning will save large amounts of money.

WHAT TYPES OF ROLLING STOCK WILL BE REQUIRED?

Rolling stock is the equipment that will be needed to move the blocks of stone around once it has been cut. Such items include front-end loaders, backhoes, shovels, trucks, derricks, etc. One of the most costly items in the development of a quarry is the rolling stock. New equipment is very expensive. Many new quarry developments contract out many of these services. Another option is lease-purchase or buying used equipment. The decision depends on the amount of capital available. If equipment is purchased, it should have a payback within 5-7 years.

WHAT TYPES OF FACILITIES WILL BE NEEDED AT THE QUARRY SITE?

Initially very little is needed. The primary need is a small multi-purpose building or trailer to house the office, scale tabulator, and worker's area. A good option would be trailer rental, which is self-contained (including restroom facilities).

WHAT ARE THE PERSONNEL REQUIREMENTS OF THE QUARRY?

In the Upper I a quarry operator will find all the necessary personnel needed to run a quarry. A high percentage of people have worked in the mining and quarry business and are very familiar with much of the equipment that is used. Experienced drillers, heavy equipment operators are plentiful. Workers will be required to operator many types of equipment. Initially 4 to 10 people are all that is needed to run a small quarry. Needs will include a quarry manager, a driller and helper, two people to operate the wire saw or belt saw, a loader/crane operator, and at least one truck driver.

Large machinery manufacturers will often work with a quarry developer in determining the types of equipment needed for a specific quarry. The following pages are an example of an equipment plan for a granite quarry, developed by Marini Quarries Group. The prices have been given in Italian lira, all subtotals for drilling, cutting, hoisting, accessories and consumables, and spare parts have been converted to US dollars. At the time of this writing,

$1 US is equal to 1,853 Italian lira. Marini has divided the equipment into four main categories. The following list gives each category and the price given by Marini converted to US Dollars.

Drilling	$21,322
Cutting	$45,181
Accessories and Consumables	$59,981
Accessories Spare Parts	$9,849
Total Amount	$136,333
Package and FOB Costs for Delivery	$6,476
Total Amount FOB North Italian Port	$142,809

APPENDIX G - Comprehensive Site List

This appendix contains the details that have been gathered on each site. The information on each site has been grouped into eight categories. The following chart shows each category and also shows a brief summary of what type of information that that particular category describes.

Stone Type	Describes the geological name for that stone.
Stone Description	Gives a more qualitative description of the stone- texture, color, etc.
County	Identifies in which county this site is located.
Site Location	Gives the plat location for this site.
Site Description	Gives a qualitative description of the location of this site - landmarks, directions to get there, etc.
Historical Notes	Gives information that we obtained from other sources, primarily Dr. Allan Johnson's MTU report.
Field Notes	Information that HJB has gathered, through field visits, on the site.

Development Potential An attempt by HJB to classify the potential each site has for quarry development.

The sites have been numbered sequentially. Al Johnson's MTU report identified 51 sites around the state of Michigan - 1-47 are these sites on the HJB list. Sites 48-51 on Al Johnson's list were located in the Lower Peninsula of Michigan, and were therefore not included in our study. On the HJB list, sites 52-80 were sites obtained from Kathryn Bishop Eckert's research - they are all sandstone sites. The remaining sites are sites that were found through suggestions by residents, through field investigations, and other methods.

Map showing collection sites

Site # 01

Stone Type	Rhyolite Porphyry
Stone Description	pinkish orange groundmass with pink feldspar and grey quartz phenocrysts
County	Ontonogan
Site Location	NW ¼, Section 20, T49N, R41W
Site Description	outcrops found on both sides of M64
Historical Notes	Outcrops of this attractive stone occur on both sides of M64 in the NW ¼ of Section 20, T49N, R42W. The rhyolite has a pinkish orange fine-grained groundmass in which are distributed larger crystals of pink feldspar and gray quartz. Outcrops weather to light shades of pink, tan, and white. Strong and closely spaced joints trend N85°E and dip 67°S. This material could be quarried by the shelf method in the development stage but eventually would become a pit operation with attendant minor water problems. There is a possibility that some large blocks could be quarried but most of the product would be crushed stone for precast concrete panel surfacing.
Field Notes	The outcropping is located on both sides of the Gogebic Hiking Trail in the Ottawa National Forest Land. All visible outcrops are on the road. There are no homes or buildings in the area. An old gravel pit is a half-mile north of the outcropping on the west side of M64. It appears there is a new gravel pit being developed on the east side of M64.
Development Potential	Good Potential

Site # 02

Stone Type	Rhyolite Porphyry
Stone Description	dark orange color
County	Ontonogan
Site Location	SE ¼, Section 3, T49N, R41W
Site Description	site is adjacent to U.S. Forest Service Road #630, accessible from Bergland by Forest Road 400 N take 400 north to FR 630 then go east
Historical Notes	A probable continuation of the same rhyolite as Sample #1 crops out in the SE ¼ of Section 3, T49N, R41W. At this locality, a prominent cliff of the dark-orange colored porphyry is exposed on the side of a prominent hill. The site is adjacent to U.S. Forest Service road number 473, which is accessible from Bergland by means of the county road which was formerly M64. Except for color, this rock is similar to Sample #1. It has a fine grained groundmass with pink crystals of feldspar and bluish-gray crystals of quartz. A shelf type quarry with no water or overburden problems could be quarried at this locality. Also, crushed rock suitable for precast concrete
Field Notes	The directions to the site are incorrect in the Historical Notes section. The correct directions are detailed in the Site Description section. There is a 150 foot sheer cliff of dark colored stone -- not orange colored. Directly on top of the cliff are two large homes.
Development Potential	No Potential

Site # 03

Stone Type	Altered Peridotite
Stone Description	green, black, white, and purple colors
County	Marquette
Site Location	NW ¼, Section 31, T48N, R27W
Site Description	belt of quarries found short distance north of US4l and town of **Ishpeming**
Historical Notes	Several quarries are located in a belt of serpentine (altered periodotite which occurs a short distance north of US4l and the town of Ishpeming. The samples examined came from the Peninsula Quarry location in the NW ¼ of Section 31, T48N, R27W. Material from this quarry and from several others has been marketed in the past, but these operations have not been financially successful although the stone is of good green, black, white, and purple colors and is said to compare favorably to the best Italian Verde Antique. Most of the stone in the area examined is of some shade of green. Much of it has a brecciated appearance and veins and stockworks of fibrous green amphibole are common. White carbonate patches and veins are also common. There are great variations in textures and allover patterns. Serpentine minerals, chlorite, carbonate, and actinolitic amphiboles are the common minerals. Pyrite, magnetite, and other opaques were noted. There are no traces of original ultramafic minerals or textures present. On the basis of the inspection of only one quarry, it appears that blocks as much as six feet square could be selectively quarried. However, smaller blocks are most abundant. With modern methods of quarrying and processing, it might be possible to market this Verde Antique. Waste from slabbing operations could be used as terrazzo stone. The location of the serpentine (including Verde Antique) belt is shown on the geologic map of the Upper Peninsula published by the Michigan Geological Survey.
Field Notes	This site has a large cliff that appears to have a large deposit of the "Verde Antique" stone. It has been previously tested and drilled by other investigators. At the prime site, a large quantity has been blasted for fill or other purposes, which will make the job of opening up a face somewhat more expensive. There has been one deep core drill hole in the center of the deposit, which was done by the Ropes Gold Mine Company, which will give the investigator an idea of the depth and quality of the stone.
Development Potential	Good Potential

Site # 04

Stone Type	Granodiorite
Stone Description	pink with seams and patches of pale yellow (weathers to light tan and
County	Marquette
Site Location	SW ¼, Section 32, T49N, R25W
Site Description	found on county highway 550, five miles NW of Marquette city limits
Historical Notes	This attractive rock was collected from a large cut on county highway 550, five miles northwest of the Marquette city limits. This particular outcrop and many others of similar material occur in the SW ¼ of Section 32, T49N, R25W. In the quarrying industry, this rock would be called a granite. It is of medium coarse texture and is pink with seams and patches of pale yellow green in many areas. Joints are numerous in the outcrops and it appears on the surface, at least, that no large blocks could be quarried. The rock weathers to shades of light tan and pinkish tan. Major minerals present are quartz and feldspar. Hornblende, chlorite, epidote, apatite, sphene, sericite, and hematite are also present. This "granite" is very attractively colored and textured and could be used as precast concrete panel aggregate. Diamond drilling in the area might reveal material massive enough for quarrying of large blocks.
Field Notes	This site is located on Sugar Loaf Mountain, approximately 4 miles outside of Marquette on Highway 550. It is located between the highway and Lake
Development Potential	No Potential

Site # 05

Stone Type	Marble
Stone Description	tan, pink, purplish pink, and hematite red
County	Marquette
Site Location	SW ¼, Section 8, T47N, R25W
Site Description	found at edge of A. Lindberg and Sons' sand and gravel operation
Historical Notes	The samples were collected from the kona dolomite formation from a small shelf type pit at the edge of A. Lindberg & Sons' sand and gravel operation in the SW ¼ of Section 8, T47N, R25W. At this location, beds of Precambrian metasediment are exposed in a vertical face rising about 60 feet above the quarry floor. Beds are four inches to six feet thick with distinct laminations within beds marked by color differences. The quarry is located in a portion of a shallow EW trending anticline. Steeply inclined joints N47°W and Nl5°E are the most prominent. Algal structures are common. There is considerable variation in color, lamination thickness bedding thickness, amount of brecciation, amount of argillaceous material, silicification. Various shades of tan, pink, purplish pink, and hematite red are common, the latter as fracture fillings in particular. Several thin sections were examined under the microscope. The common mineral is carbonate which is on the dolomitic side (MgO 18.20%). The minor amounts of quartz present appear to have been introduced during weak metamorphism. Hematite is present as a replacement and filling of fractures. The kona could be cut and used as a dimension stone or crushed and screened for use as precast concrete panel aggregate. Decorative panels at
Field Notes	The Lindberg and Sons sand and gravel operation is on one side of County Road 480 and there is an abandoned quarry on the other side of the road. The abandoned quarry is flooded with water. The stone appears very weathered.
Development Potential	No Potential

Site # 06

Stone Type	Dolostone
Stone Description	color ranges in shades of blue grey to tan
County	Alger
Site Location	SE ¼, Section 24, T46N, RI8W
Site Description	found in old quarry operated by A. Lindberg and Sons, off of M28 on Percy
Historical Notes	A quarry in Ordovician sediments exposed in the SE ¼of Section 24, T45N, RI8W, was operated by A. Lindberg & Sons for aggregate on nearby highway M28. The quarry walls, about 30 feet high, show distinct, sandy dolostone beds from 3 to 12 inches thick but commonly 8 to 10 inches. This stone ranges in color from blue-gray to various shades of tan. Naturally weathered surfaces are tan to buff in color. Widely spaced vertical joints trend N68°E and N43°W. A minor joint trend is N29°E. In the sample examined with the microscope the major minerals were calcite and dolomite with scattered clastic grains of quartz, hematite, and a few zircons. Some hematite staining was noted. Minute cavities paralleling the layering were noted in most beds. Large quantities of this stone could be quarried with a pit operation involving very slight water and overburden problems.
Field Notes	Located l mile west of Shingleton. This is an old quarry operated by Lindberg and Sons. The stone is a brown to tan colored dolostone that is
Development Potential	No Potential

Site # 07a

Stone Type	Sandstone
Stone Description	red and tan colors
County	Alger
Site Location	Section 26, T47N, R21W
Site Description	inactive Brownstone Quarry
Historical Notes	There are extensive deposits but relatively few outcrops of Cambrian sandstone in the northern part of Alger County. More information concerning these sediments can be obtained from the 1958 report of W.H. Hamblin. A quarry in Section 26, T47N, R21W, now known as the Brownstone Quarry, has supplied dimension stone in the past, but is currently inactive. The Alger Stone Company of Munising has from time to time quarried stone from a site alongside U.S.F.S. road 2484 in the NW ¼ of Section 18, T47N, R21W. Here the rock occurs in the upper part of the Cambrian Jacobsville and the usual red and light tan, medium-grained sandstone is exposed. Flat lying beds one to fourteen inches thick are present with thicker beds showing crossbedding. A major joint set trends N80°W. Mineralogically, the rock consists of about 75% quartz together with microcline, plagioclase, muscovite, hornblende, garnet, leucoxene, and lithic fragments of chert, slate, basalt, and felsite. The sand grains are angular to subrounded. Both the white and red sandstones are very porous and poorly cemented. Cementing materials are quartz, sericite, and iron oxide with the latter absent in the light colored sandstones.
Field Notes	This site is the location of the pre-existing Brownstone Quarry. The Lindberg Construction Company, when building the new M28, filled in the old quarry (around 1975). The quarry is estimated to be less than 100 yards off of M28. Currently there is a large clearing area, which would be a good place for test drilling.
Development Potential	Good Potential

Site # 07b

Stone Type	Sandstone
Stone Description	red and tan colors
County	Alger
Site Location	NW ¼, Section 18, T47N, R21W
Site Description	found off of USPS road 2484 (Alger Stone Company of Munising)
Historical Notes	There are extensive deposits but relatively few outcrops of Cambrian sandstone in the northern part of Alger County. More information concerning these sediments can be obtained from the 1958 report of W.H. Hamblin. these sediments can be obtained from the 1958 report ofW.H. Hamblin. A quarry in Section 26, T47N, R21W, now known as the Brownstone Quarry, has supplied dimension stone in the past, but is currently inactive. The Alger Stone Company of Munising has from time to time quarried stone from a site alongside U.S.F.S. road 2484 in the NW ¼ of Section 18, T47N, R21W. Here the rock occurs in the upper part of the Cambrian Jacobsville and the usual red and light tan, medium grained sandstone is exposed. Flat lying beds one to fourteen inches thick are present with thicker beds showing crossbedding. A major joint set trends N80°W. Mineralogically, the rock consists of about 75% quartz together with microcline, plagioclase, muscovite, hornblende, garnet, leucoxene, and lithic fragments of chert, slate, basalt, and felsite. The sand grains are angular to subrounded. Both the white and red sandstones are very porous and poorly cemented. Cementing materials are quartz, sericite, and iron oxide with the latter absent in the light-colored sandstones.
Field Notes	This site is located in outcrops along Old M28. The railroad runs parallel to this road. Bob Glatus had previously quarried sandstone from a three foot ledge at this site. The old quarry is located on the south side of the road.
Development Potential	Little Potential

Site # 08

Stone Type	Granodiorite
Stone Description	grayish pink groundmass with pink feldspar phenocrysts
County	Marquette
Site Location	NW ¼, SW ¼, Section 14, T48N, R26W
Site Description	found in a road cut on county highway 510
Historical Notes	A grayish-pink medium to coarse-grained rock with large pink feldspar crystals crops out over a large area near the Dead River storage basin. The sample studied was collected from a roadcut on county highway 510 in the NW ¼ of the SW ¼ of Section 14, T48N, R26W. In this area, there are many glaciated knobs of the "granite" free of overburden and easily quarried with a shelf type operation. Glaciated surfaces show no appreciable weathering or discoloring. The pluton of which the sample is a part has been described as a syenite but thin-section study of this particular sample shows that it is composed of about 50% oligoclase, 10% orthoclase, and 20% quarts. These are the major minerals in a granodiorite. Minerals present in addition to the above are chlorite, epidote, carbonate, apatite, zircon, sericite, and opaques. This rock is suitable for precast concrete panel aggregate, and drilling in selected areas might reveal massive material suitable for quarrying of large stones.
Field Notes	This site is located in an outcrop on Highway 510. The stone deposit is green and pink in color.
Development Potential	No Potential

Site # 09

Stone Type	Granite
Stone Description	pink to orange color
County	Marquette
Site Location	NW ¼, SW ¼, Section 32, T47N, R26W
Site Description	found in road cut near M35, 6 miles south of Palmer village limits
Historical Notes	Pink to orange granite is exposed in a road cut near M35 six miles south of the Palmer village limit line. This outcrop is located in the NW ¼ of the SW ¼ of Section 32, T47N, R26W. Similar pink to orange granite crops out in at least two other areas in this part of Marquette County. Major minerals are orthoclase, calcic oligoclase, and quartz. Other minerals present are aptite, chlorite, and limonite. The color of this granite is due to distribution of iron oxide along fractures and cleavages of the minerals present. Exploration might turn up areas were large blocks of this granite could be quarried, but the surface exposures in the outcrops visited are badly jointed and the rock would not be suitable for other than use as precast concrete panel aggregate.
Field Notes	The material along the road is well shot and there are no large pieces to be seen. There are three separate outcroppings and one big cliff. The stone has quite a bit of quartz in it.
Development Potential	Good Potential

Site # 10

Stone Type	Sandstone
Stone Description	red and white colors
County	Baraga
Site Location	Section 34, T52N, R33W
Site Description	found on quarry that is adjacent to US41 and Soc Line Railroad
Historical Notes	A small quarry in the Cambrian Jacobsville sandstone is located in Section 34, T52N, R33W, but the quarry has not been operated since 1970. This site is adjacent to US41 and the Soc Line Railroad. A bulk sample of this red and white sandstone was collected from the quarry. The beds strike N20°E and dip 4°N and are generally variable in thickness. Thicknesses from 2-½ to 5 inches are cut into 4-inch wide veneer slabs. The marketed material consists of a mixture of red and white stone. A thin section of the common rock type indicates that most of the poorly cemented and friable rock is made up of angular to subrounded quartz grains. Clastic fragments of basalt, felsite, feldspar, apatite, zircon, and tourmaline were noted. Ocherous hematite or hematite-stained clay is sparsely distributed in intergranular areas. Many outcrops of Jacobsville occur in this section of Baraga County and details of distribution and petrology may be obtained from the reports of Hamblin (1958) and Denning (1949).
Field Notes	Many outcroppings of sandstone are found in this area. The area is fairly heavily populated.
Development Potential	No Potential

Site # 11

Stone Type	Red Jaspilite
Stone Description	red and steel grey banded color
County	Marquette
Site Location	NE ¼, Section 10, T47N, R27W
Site Description	found at Jasper Knob in Ishpeming

Historical Notes	Attractive red and steel-gray banded jaspilite is found in quite a number of localities in Marquette County. This particular sample came from the NE ¼ of Section 10, T47N, R27W. At this locality in the city of Ishpeming, the formation crops out on a prominent hill known locally as Jasper Knob. The banding of this stone is distinctive. Red jasper bands up to 2 inches thick are interlayered with steel-gray hematite bands which have similar variations in thickness. At Jasper Knob, the jaspilite has been intricately folded, contorted and recrystallized. Quartz and Hematite are the major minerals present. Jaspilite cuts and polishes well and many small decorative objects such as pen set bases, paperweights and the like may be made from the stone. Crushed and screened jaspilite makes an attractive surfacing for precast concrete decorative panels.
Field Notes	Jasper Knob is located in the town of Ishpeming. This area has been fully developed
Development Potential	No Potential

Site # 12

Stone Type	Granite
Stone Description	grey, med. grain, granite- 70% orthoclase & microcline, about **20% quartz & 10% plagioclase (.AN15)**
County	Marquette
Site Location	NE ¼, SE ¼, Section 20, T46N, R25W
Site Description	Marquette County highway #533 found 3 miles to east
Historical Notes	Sample #12 is a medium-grained gray granite with 70% orthoclase and microcline, about 20% quartz and 10% plagioclase (Anl5). These granitic rocks are badly jointed and it appears that the material now exposed in the pits would only be suitable for precast panel aggregate. Other glaciated granitic knobs rise above the sand planes in this part of the country and these should be investigated in more detail. Several pits were opened up in these granites and the material used as blacktop aggregate. The pits are located in the NE ¼ of the SE ¼ of Section 20, T46N, R25W. Rail loading facilities are present 1.2 miles east of the pits and Marquette County highway number 533 is three miles to the east.
Field Notes	Not Available.
Development Potential	No Potential

Site # 13

Stone Type	Granite
Stone Description	rusty pink, med. grain, granite - 50% perthitic microcline, 35 to 40% oligoclase and 10% quartz.
County	Marquette
Site Location	NE ¼, SE ¼, Section 20, T46N, R25W
Site Description	Marquette County highway #533 found 3 miles to east
Historical Notes	Sample #13 is a rusty-pink colored medium-grained rock with about 50% pathetic microcline, 35 to 40% oligoclase, and 10% quartz. This granite then is closer to being a quartz monzonite. These granitic rocks are badly jointed and it appears that the material now exposed in the pits would only be suitable for precast panel aggregate. Other glaciated granitic knobs rise above the sand planes in this part of the country and these should be investigated in more detail. Several pits were opened up in these granites and the material used as blacktop aggregate. The pits are located in the NE ¼ of the SE ¼ of Section 20-, T46N, R25W. Rail loading facilities are present 1.2 miles east of the pits and Marquette County highway number 533 is three miles to the east.
Field Notes	Not Available.
Development Potential	No Potential

Site # 14

Stone Type	Granite
Stone Description	grey, fine grained quartz monzonite
County	Marquette
Site Location	NE ¼, SE ¼, Section 20, T46N, R25W
Site Description	Marquette County highway #533 found 3 miles to east
Historical Notes	Sample #14 is a fine-grained gray quartz monzonite. These granitic rocks are badly jointed and it appears that the material now exposed in the pits would only be suitable for precast panel aggregate. Other glaciated granitic knobs rise above the sand planes in this part of the country and these should be investigated in more detail. Several pits were opened up in these granites and the material used as blacktop aggregate. The pits are located in the NE ¼ of the SE ¼ of Section 20-, T46N, R25W. Rail loading facilities are present 1.2 miles east of the pits and Marquette County highway number 533 is three miles to the east.
Field Notes	Not Available.
Development Potential	No Potential

Site # 15

Stone Type	Metadiabase Stone
Stone Description	dark sage green
County	Marquette
Site Location	SE ¼, Section 35, T48N, R27W
Site Description	found in railroad cut- found in railroad cut
Historical Notes	The sample was taken from a railroad cut located in the SE ¼ of Section 35, T48N, R27W. Similar altered diabasic and dioritic intrusives are common in the Animikian rocks in this section of Marquette County. The stone is dark sage green in color and very uniformly fine-grained. In thin section, the metadiabase consists of altered plagiocase feldspar together with actinolictic hornblende, epidote, chlorite, opaques, and small amounts of quarts. As a decorative stone, it would be suitable only for precast panel aggregate.
Field Notes	Found a dark reddish brown stone. Sample was taken from behind the National Guard Armory Building.
Development Potential	No Potential

Site # 16

Stone Type	Black Jaspilite
Stone Description	black with steel grey bands
County	Marquette
Site Location	SE ¼, Section 10, T47N, R29W
Site Description	found near Humboldt Mine

Historical Notes	Sample 16 came from the poor rock pile and tailings dam located in the SE ¼ of Section 10, T47N, R28W near the Humboldt Mine. Large quantities are available in separate piles in the area and more could be removed from bedrock localities in the Humboldt pit. Black jaspilite is a banded and contorted rock consisting of black recrystallized chert interlaminated with steel gray hematite and magnetite. The material takes an excellent polish and is very attractive when made up into small polished tiles and desk ornaments. Because there is a strong color contrast between the black chert and the sparkling metallic sheen of hematite, it would make a striking aggregate for surfacing precast concrete
Field Notes	this site is located near the Humboldt mine area. Many spoil piles are located in this area from the iron ore mines. There is very little overburden.
Development Potential	No Potential

Site # 17

Stone Type	Amphibolite
Stone Description	dark colors (black)
County	Marquette
Site Location	NE ¼, NE ¼, Section 32, T47N, R29W
Site Description	found in road cut on Marquette county highway 601
Historical Notes	This very fine-grained, equigranular, and very black rock crops out in a road cut on Marquette County highway 601 in the NE ¼ of the NE ¼ of Section 32, T47N, R29W. Continuations of the same mass crop out in NW ¼, NW ¼ of Section 33, and SE ¼. SE ¼ of Section 29. Both of these localities are in T47N, R29W. A weak schistosity (direction of easy breaking) is vertical and trends N57°W. Specimens which break along the schistosity show brilliant reflections from subaligned minerals. In thin section the dominant minerals are dark colored hornblende and plagioclase (An35). Minor amounts of quartz, apatite, magnetite, and biotite were also noted. This amphibolite could be used as a "black" in terrazzo or precast panel aggregate.
Field Notes	Several outcroppings are located in and around the town of Republic on M95 and 601. Colors do not look very marketable.
Development Potential	No Potential

Site # 18 A

Stone Type	Granite Porphyry
Stone Description	grey groundmass with light pink phenocrysts
County	Marquette
Site Location	NE ¼, Section 1, T46N, R30W
Site Description	found in outcrops along M95
Historical Notes	This attractive stone crops out along M95 in the NE ¼ of Section 1, T46N, R30W. Light pink feldspar crystals in a finer-grained gray groundmass combine to form a very distinctive and good looking decorative stone. The pink feldspars average about one-half of an inch in size. Joints are widely spaced and very large blocks could be quarried from this location. Exposed surfaces are gray and show only slight weathering. Under the microscope, a thin section of this sample shows that microcline forms at least 50% of the rock, quartz 30% and oligoclase about 10%. Biotite, muscovite, sphene and carbonate are also present. This is the only locality noted during this investigation where large unjointed blocks of granite could be quarried at the surface. This stone is suitable, on the basis of massive character, color, and texture for use as large polished or unpolished decorative slabs
Field Notes	Several outcroppings found around Michigamme River, near M95 and M41. This area seems to have a fairly large deposit of gray and pink colored stone. There is some development in the area.

Development Potential	Little Potential

Site # 18 C

Stone Type	Granite Porphyry
Stone Description	This stone is a pink colored granite with flecks of black.
County	Marquette
Site Location	Section 23 T47N R29W
Site Description	See Field Notes
Historical Notes	Not Available.
Field Notes	This site is a recent clear cut area. Several outcroppings are visible of a very consistent light red to pink stone on the surface. The interesting thing about this site is that the stone is quite contiguous relatively free of fractures and color is consistent over a half mile area. This site shows the best promise for monument stone.
Development Potential	Good Potential

Site # 20

Stone Type	Tremolitic Marble
Stone Description	crystalline and white, pink, pale green and sometimes faintly blue
County	Dickinson
Site Location	NE ¼ of the SE ¼ Section of 34, T42N, R30W
Site Description	found in newly developed rock cut in a prominent ridge of Randville dolomite
Historical Notes	There are several old quarries in this immediate area, but the sample came from a newly developed cut in a prominent ridge of Randville dolomite located in the NE ¼ of the SE ¼ of Section 34, T42N, R30W. The narrow shelf type quarry is adjacent to a dirt road and one mile east of m95 and the railroad at Randville. The quarry rock here is visibly crystalline and white, pink, pale green, and sometimes faintly blue colored. Relict bedding strikes N20°E and dips 77°N. Prominent jointing trends N45°W and dips 25°N. An average specimen was thin-sectioned and examined under the microscope. The minerals are carbonate and tremolite. Marble from this area had been quarried for many years and used for terrazzo stone and other purposes. A mixture of colored and white marble would perhaps be suitable for precast concrete panel aggregate. It might also find limited use as the raw material for various products of the lapidary arts such as polished bases for pen sets, paperweights, and other objects. Sample # 20 was collected from property now owned by Great Lakes Select
Field Notes	This site is an exploratory opening in an outrcropping east of Randville on Old 69. The opening is 30 feet wide by 50 feet deep and is quite seamy. This site is on the west entrance to the Groveland Mine.
Development Potential	No Potential

Site # 21

Stone Type	Sandstone
Stone Description	colors range from buff to tannish yellow to orange, and brick red
County	Dickinson
Site Location	SW ¼, Section 30, T42N, R29W
Site Description	found at Groveland Mine area

Historical Notes	This specimen comes from the Groveland Mine area in the SW ¼ of Section 30, T42N, R29W. It is probably of the same age as specimen #36 and certainly it is similar to it mineralogically. Colors of this carbonate cemented sandstone range from buff to tannish yellow, orange, and brick red. Flat lying beds 8 to 12 inches thick occur. Some beds are conglomeritic. Minerals present, in addition to the dominant quartz, are feldspar, garnet, monazite, and zircon.
Field Notes	This site is located inside the Groveland Mine. The colors are not impressive.
Development Potential	No Potential

Site # 22

Stone Type	Amphibolite
Stone Description	very dark green color
County	Dickinson
Site Location	SW ¼, SE ¼, Section 30, T42N, R29W
Site Description	found not far from Groveland Mine hard surfaced road
Historical Notes	This black rock comes from a quarry operated intermittently for terrazzo stone and precast concrete aggregate. It is located in the SW ¼ of the SE ¼ of Section 30, T42N, R29N, R29W not far from the Groveland Mine hard surfaced road. In outcrop the rock schistosity strikes EW and dips 73°N. Pronounced jointing trends N10°E and dips 67°N. Weathered surfaces of this rock are rusty brown colored. The rock consists mainly of very dark green hornblende, Andesine feldspar, biotite, sphene, apatite, magnetite, and quartz are relatively minor constituents. A striking feature of this black rock is the glistening of the amphibole in faces broken parallel to the grain (schistosity).
Field Notes	This site is found inside of the Groveland Mine.
Development Potential	No Potential

Site # 23

Stone Type	Pegmatite
Stone Description	pink to orange color
County	Dickinson
Site Location	NW ¼, SW ¼, Section 20, T42N, R29W
Site Description	outcrop found at point north of M69 which is 4.5 miles east of the junction of M69 and M95 This massive pink to orange pegmatite is exposed as a lens shaped knob rising nearly 80 feet above the general level. It crops out for a distance of about 400 feet in the east-west direction. The strikes of the enclosing metamorphic rocks are also east-west. As a whole, the pegmatite shows little jointing, sheeting, or fracturing. Microcline is the major mineral in the rock. It is both perthitic and poikilitic with albite as the second feldspar in both situations. Small amounts of quartz are present. Muscovite is also present and is the greatest drawback to extensive use of this pegmatite as terrazzo stone or precast concrete panel aggregates. Site Visit -April 1998 - The Pegmatite deposit is .3 miles east of Groveland Mine Road and M-69. This deposit is the most solid piece of mineral seen so far. Pink and gray in color, the deposit appears small. The outcropping is more like 60 ft. high by 300 ft. wide vs. 80 ft. high by 400 ft. long as in the report. The south face of the outcropping has been shot off at some time. Once inch bore holes are exposed on the face. After further exploring, a climb to the top exposed a larger deposit running to the north. 300 ft. from the face is a new home, possibly a weekend get away or hunting camp. If the mineral quality is good, this site has the most potential to date. Samples

Field Notes	The outcropping is more like 60 ft. high by 300 ft. wide vs. 80 ft. high by 400 ft. long as in the report. The south face of the outcropping has been shot off at some time. Once inch bore holes are exposed on the face. After further exploring, a climb to the top exposed a larger deposit running to the north. 300 ft. from the face is a new home, possibly a weekend get away or camp.
Development Potential	Good Potential

Site # 24

Stone Type	Granite
Stone Description	pink color
County	Dickinson
Site Location	S112 of Section 26, T42N, R28W
Site Description	found in dikes of Felch Quarry Co.
Historical Notes	This sample is an attractive pink granite or coarse aplite from one of several dikes which cut the workings of the Felch Quarry Company operations in the south one-half of Section 26, T42N, R28W. The dike sampled strikes N30°E, dips 58°N and is 2-112 to 3 feet wide at the surface but widens to l 0 or 12 feet underground. Sample #24 is fresh material from the wide part of the dike. On the surface the rock is resistant, but does weather slightly to shades of tan. Mineralogically, the dike consists of quartz, orthoclase, and plagioclase (Anl5). Minor amounts of apatite, magnetite, sphene, tremolite, actinolite, and muscovite are also present. This granitic rock is resistant, attractively colored and it should be suitable for use in precast concrete panel aggregate.
Field Notes	This deposit is pink in color. The stone found is crushed and crumbled and does not appear to be very high quality.
Development Potential	No Potential

Site # 25

Stone Type	Marble
Stone Description	mostly clean white color, some green, pink, greenish yellow, grey present
County	Dickinson
Site Location	Sl/2, Section 26, T42N, R28W
Site Description	found in Felch Quarry Company
Historical Notes	This sample is from the Felch Quarry Company operation in the south one-half of Section 26, T42N, R28W. At this locality, the Randville dolomite has been recrystallized into a coarse-grained marble which frequently has pale green tremolite present. Most of the marble is clean white, but pale green, pink, greenish yellow, and gray colors also are present. Colored varieties are most common in contact zones adjacent to the dike rocks which cut the formations. Tremolite and dolomite are the minerals noted in thin-section. Blades of tremolite up to two inches in length have been noted, but most are much
Field Notes	A part-time crushing operation is operating at this site. The deposit appears to be very seamy. The older part of the quarry is filled with water.
Development Potential	No Potential

Site # 26

Stone Type	Quartz-Diorite
Stone Description	colors range from mottled green to tan, black, and white
County	Marquette
Site Location	SE ¼, SE ¼, Section 30, T49N, R25W
Site Description	found in outcrops along Marquette County highway 550
Historical Notes	The sample was collected from outcrops alone Marquette County highway 550 in the SE ¼ of the SE ¼ of Section 30, T49N, R25W. This rock is medium to coarse grained and is locally veined with pale yellowish green epidote. Colors range from mottled green to tan, black, and white mixtures. Glaciated outcrops have weathered to tan and white but surfaces are not decomposed. There are many acres of exposures free of overburden and with sufficient relief that a shelf type quarrying operation free of water problems could be conducted. At least 55% of the stone is composed of sericitized plagioclase feldspar (An25) and 35% of the rock is quartz. Minor amounts of orthoclase, green hornblende, epidote, and sphene are present. The texture and color variation make this rock suitable for precast concrete panel aggregate.
Field Notes	This site is located on Sugar Loaf Mountain, approximately 4 miles outside of Marquette on Highway 550. It is located between the highway and Lake
Development Potential	No Potential

Site # 27

Stone Type	Quartz-Diorite
Stone Description	pink color
County	Marquette
Site Location	SE ¼, SE ¼, Section 4, T48N, R25W
Site Description	adjacent to Marquette County Highway 550 and the railroad
Historical Notes	Outcrops of this rock are common in the SE ¼ of the SE ¼ of Section 4, T48N, R25W. The same rock is also found in the SW ¼ of Section 3, T48N, R25W. Both areas are adjacent to Marquette County highway 550 and the railroad. This stone is pink and medium grained and would be considered a "granite" by the stone industry. Outcrops of the stone are much jointed and joint surfaces are frequently coated with chlorite. Large quantifies of this stone are available in the area. Mineralogically the "granite" is similar to sample #26 except that this specimen shows lineation and is slightly altered. Feldspars are colored red with oxide and this accounts for the reddish hue of the granite. As a decorative stone, this would best be used as precast concrete panel
Field Notes	This site is located very near the Dead River Power Plant. There are large surface boulders and no overburden. The stone is a pink color.
Development Potential	No Potential

Site # 28

Stone Type	Altered Gabbro
Stone Description	dark green with pink and light green patches
County	Marquette
Site Location	SE ¼, NW ¼, Section 10, T48N, R25W
Site Description	found ¼ mile W of County Highway 550, ¼ mile S of Lake **Superior and Ishpeming Railroad**

Historical Notes	About a quarter of a mile west of County Highway 550 and the same distance south of the Lake Superior and Ishpeming Railroad is a mass of altered gabbro that rises above the general level. This location, known as the Longyear quarry, is in the SE ¼ of the NW ¼ of Section 10, T48N, R25W. The gabbro is dark green with occasional pink and light green patches, and the texture is medium to coarse grained. Many directions of jointing cut the quarry walls. Very little rock remains to be quarried here without going into a pit type operation. However, this rock is suitable only for precast concrete panel aggregate and there is considerable tonnage available without much additional development work. Minerals present include altered feldspar (Andesine) and actinolitic hornblende. Other minerals present in small quantities are chlorite, epidote, carbonate, and magnetite.
Field Notes	This site's main deposit is bordered by the Dead River Power Company, a small lake, and Highway 550. This area is not able to be quarried.
Development Potential	No Potential

Site # 29

Stone Type	Quartzite
Stone Description	off-white to grey, glassy color
County	Marquette
Site Location	SE ¼, Section 36, T48N, R25W
Site Description	See Field Notes.
Historical Notes	Off-white to gray, glassy quartzite crops out in many parts of Marquette County. This particular sample came from an outcrop of the Precambrian Mesnard quartzite located in the SE ¼ of Section 36, T48N, R25W. At this locality, beds one to thirty inches thick were noted, but a range from eight to sixteen inches is most common. The formation strikes N88°W and dips 85°S. A thin section of the quartzite shows that it consists of a mosaic of interlocked quartz with slight amounts of interstitial iron oxide. If the off-white to gray colors were acceptable, this glassy quartzite would
Field Notes	this site is located near the travel center, the prison and M4l. This site is unquarryable due to its location.
Development Potential	No Potential

Site # 30

Stone Type	Marble
Stone Description	pink to purple and pinkish tan to brown in color
County	Marquette
Site Location	SW ¼, NW ¼, Section 6, T47N, R24W
Site Description	found in outcrop that lies 40 feet west of US4l
Historical Notes	Massive algal reefs within the kona dolomite occur in the SW ¼ of NW ¼ of Section 6, T47N, R24W. The outcrop from which samples of marble were collected lies about forty feet west of US4l which parallels the Soo Line Railroad roadbed. Bedding is indistinct in the outcrop but algal structures stand out as slightly silicified convex upward arcs with chords several feet in length. The marble is pink to purple and pinkish tan to brown in color. Curved algal structures show up in polished slabs as parallel curved bands of contrasting colors. This marble is quite coarse grained and mineralogically simple. Cherty-appearing quartz and disseminated hematite were present in the thin sections examined. Jointing is inconspicuous in the outcrop area and blocks twelve feet square could be quarried. The stone is attractively colored and takes an excellent polish. Four by eight-foot or larger decorative slabs could be cut from this material and waste rock would find use as an attractively colored precast
Field Notes	This site is an old quarry with a l 00 foot face directly across M4l from the Michigan Welcoming Center, just east of Marquette. The stone is a purple to pink color.

Development Potential	No Potential

Site # 31

Stone Type	Quartzite
Stone Description	white to faint green color
County	Marquette
Site Location	Section 32 T48N R26W
Site Description	found at outcrops as a prominent ridge on US 41 at east city limits of Negaunee.
Historical Notes	Another quartzite (Precambrian Ajibic formation) crops out as a prominent ridge cut by US 41 at the eastern city limits of Negaunee. Colors are white to faint green. Some beds have numerous dark green spots that are to 3/8 inches in diameter. East-west striking beds one to ten feet thick dip 57°S. Jointing is irregular and joint surfaces are frequently coated with ocherous hematite. This quartzite is glassy and hard and would perhaps be a satisfactory precast concrete panel aggregate. Another quartzite (Precambrian Ajibic formation) crops out as a prominent ridge cut by US 41 at the eastern city limits of Negaunee. Colors are white to faint green. Some beds have numerous dark green spots that are to 3/8 inches in diameter. East-west striking beds one to ten feet thick dip 57°S. Jointing is irregular and joint surfaces are frequently coated with ocherous hematite. This quartzite is glassy and hard and would perhaps be a satisfactory precast concrete panel aggregate.
Field Notes	This site is in the city of Negaunee with several businesses in close proximity. There is a very small deposit of the stone on the surface.
Development Potential	No Potential

Site # 32

Stone Type	Quartzite
Stone Description	dark grey and bluish grey color
County	Marquette
Site Location	Section 32 T48N R26W
Site Description	found at outcrops as a prominent ridge on US 41 at east city limits of
Historical Notes	This dark gray and bluish gray quartzite is part of the Precambrian Siamo formation which forms a ridge that is cut by US 41 at the east city limit of Negaunee. The rock is fine-grained, equigranular, and is not glassy like the Mesnard and Ajibic quartzites. Beds twenty inches to three and one half feet thick strike N82°W and dip 70°S. Joints are irregular and generally nearly at right angles to the bedding. Weathered surfaces are tan to rusty brown colored. This quartzite is suitable as a decorative surfacing for precast concrete
Field Notes	This site is in the city of Negaunee with several businesses in close proximity. There is a very small deposit of the stone on the surface.
Development Potential	No Potential

Site # 33

Stone Type	Felsite Conglomerate
Stone Description	tan and orange with some rust red, reddish brown, and reddish orange
County	Houghton
Site Location	SE ¼, NE ¼, Section 8, T55N, R33W

Site Description	found in waste rock piles adjacent to shafts of inactive Boston mines
Historical Notes	Three waste rock piles of conglomerate are located in the SE ¼ of the NE ¼ of Section 8, T54N, R33W adjacent to the shafts of the inactive Boston location mines. This conglomerate consists of tightly cemented sand, pebbles, cobbles, and boulders of several felsitic rocks. Colors of these materials are dominantly various shades of tan and orange but some rust-red, reddish brown and reddish orange rocks are present. No attempt was made to study the mineralogy of all rock types present, but common varieties consist largely of fine-grained feldspar and quartz which are both discolored with iron oxide. The conglomerate is cemented firmly with carbonate and quartz. Crushed and screened conglomerate is attractively colored, and it could be used either alone or combined with contrasting colored rock as precast concrete panel aggregate.
Field Notes	Samples of crumbled stone. Does not have potential for dimension stone.
Development Potential	No Potential

Site # 34

Stone Type	Altered Gabbro
Stone Description	black color
County	Baraga
Site Location	NW ¼, Section 22, T48N, R31W
Site Description	found in road cut on US 41 (other sites nearby)
Historical Notes	This rock type, which the building stone trade would call Black granite, crops out in the NW ¼ of Section 22, T48N, R31W. The material is coarse grained with many large (½ to % inch) amphiboles whose distinct cleavages give the rock an excellent reflective quality. The sample obtained came from a road cut on US 41 and thus could not be quarried. However, the outcrop area is quite extensive and it could be quarried in nearby sites. Prominent joints cut the rock along three distinct trends and thus large flawless blocks could not be obtained. Mineralogically, the rock consists of actinolitic hornblende, biotite, albite, together with minor amounts of magnetite, chlorite, and quartz. This black rock is probably most suitable for precast concrete panel
Field Notes	Deposit is very fragmented and will not work for dimension stone.
Development Potential	No Potential

Site # 35

Stone Type	Quartzite
Stone Description	tan, off-white, and very light grey
County	Baraga
Site Location	Section 28, T51N, R31W
Site Description	found in area adjacent to county road from Huron Bay to Arvon
Historical Notes	Tan, off-white, and very light gray quartzite crops out in Section 28, T51N, R31W. The locality is adjacent to the county road from Huron Bay to Arvon. No overburden or water problems would be encountered in quarrying this material for precast concrete panel aggregate. A sample examined in thin-section shows clastic quartz grains cemented with quartz and very slight traces of iron oxide.
Field Notes	Based on the stone type and the colors of the stone, this site would not produce marketable dimension stone.
Development Potential	No Potential

Site # 36

Stone Type	Sandstone
Stone Description	tan, buff, reddish-brown color (weathers to dark color)
County	Dickinson
Site Location	SW ¼, NW ¼, Section 4, T42N, R30W
Site Description	found in an outcrop adjacent to M95
Historical Notes	An outcrop adjacent to M95 in the SW ¼ of the NW ¼ of Section 4, T42N, R30W consists of distinctly bedded tan, buff and reddish brown colored sandstone that is most likely one of the several outliers of the Miner's Castle Member of the Cambrian Munising sandstone. The stone weathers to a dark brown color. Beds from 3 to 9 inches in thickness appear in this outcrop. Jointing is widely spaced and not common. Well-rounded but poorly sorted grains of quartz, feldspar, opaques, and garnet were noted. The cementing material is carbonate that is, in some areas, stained with limonite. The combination of attractive colors, distinct bedding, and widely spaced joints make this an ideallocation for quarrying of dimension stone. The outcrop is at the west edge of a 20 to 25 acre hilltop covered with a thin soil and underlain by nearly flat lying sandstone.
Field Notes	This outcropping is 3 miles south of Sagola on M95. The sandstone ridge runs east and west. There are a few outcroppings in the area. The sandstone is a reddish color.
Development Potential	Little Potential

Site # 37

Stone Type	Granite Gneiss
Stone Description	grey and white background with pink crystals
County	Dickinson
Site Location	SE ¼, Section 21, T42N, R30W
Site Description	found in outcrops that appear as low rounded knobs extending eastward
Historical Notes	Outcrops of this granitic rock appear as low-rounded knobs extending eastward from M95 in the SE ¼ Section 21, T42N, R30W. Fresh exposures are available 40 or 50 feet east of the highway in a knob trenched for a pipeline. The major outcrop area is about 200 feet wide and ':14 of a mile long. The granitic rock shows a distinct linear element (gneissose structure) and randomly spaced joints. At the surface at least, it appears that non flawless large blocks could be quarried. Pink feldspar crystals are rather evenly scattered in a gray and white background and the rock is very attractive. Major minerals present are quartz, feldspar, hornblende, and mica. This rock weathers to a dirty gray color beneath a soil cover and to white and tan on exposed surfaces. Drilling in the area might reveal granite suitable for large decorative panels. From surface indications, however, it appears most suitable as precast panel
Field Notes	there are several small knobs in the area around M95, north of M69. The deposit appears to have seams.
Development Potential	No Potential

Site # 38

Stone Type	Dolostone
Stone Description	mostly pink with some grey, tannish pink, and bluish grey colors
County	Dickinson
Site Location	NW ¼, NW ¼, Section 9, T39N, R29W

Site Description	found in quarry east of Strawberry Lake and on the north edge of village of
Historical Notes	This dolomite rock crops out in many parts of the county. It is well exposed in a road metal quarry located in the NW ¼ of the NW ¼ of Section 9, T39N, R24W. The quarry is east of Strawberry Lake and on the northern edge of the village of Norway. Much of the rock is pink, but various shades of grays, tannish pink and bluish gray also are present. Joints and bedding planes are so abundant that the rock would only be suitable for decorative aggregate. Mineralogically, the very fine-grained Randville in this area consists of a very few grains of quartz in a dominantly dolomitic groundmass. Several specimens showed minute quartz filled veinlets. Cherty horizons as well as layers showing algal structure were also noted. Randville dolomite from this quarry shows little, if any, effects of metamorphism. This dolomite rock crops out in many parts of the county. It is well exposed in a road metal quarry located in the NW ¼ of the NW ¼ of Section 9, T39N, R24W.
Field Notes	this site is located in the center of the town of Norway. The quarry is full of water and is now a part of Strawberry Park.
Development Potential	No Potential

Site # 39

Stone Type	Dolostone
Stone Description	grey and various shades of tangrey and various shades of tan
County	Schoolcraft
Site Location	NE ¼, SW ¼, Section 14, T42N, RI6W
Site Description	found adjacent to M94, 7 miles north of Manistique in a quarry owned by the county- found adjacent to M94, 7 miles north of Manistique in a quarry owned by the county
Historical Notes	A quarry that is reportedly owned by Schoolcraft County is located adjacent to M94 about seven miles north of Manistique. It is in the NE ¼ of the SW ¼ of Section 14, T42N, RI6W. At this locality, well-bedded dolostone of the Burnt Bluff group of sediments are exposed in the thirty-foot high quarry walls. Beds range from two to ten inches thick and are gray and various shades of tan in color. The sediments are very fine grained and break easily with subconchoidal fractures. Some layers are as fine grained as the famous Solenhofen lithographic limestone. Bedding at this quarry is essentially flat lying although the regional dip is southward at a low angle. The lower twenty feet of the section is good dimension material that greatly resembles the Lannon stone of the Sussez-Lannon area of Wisconsin. In thin section, the stone is very fine-grained with many rhombic shaped crystals of dolomite present. Very little quartz appeared in the single thin section examined. The dolostone does not deteriorate under exposure to severe Michigan winters and does not change color notably during weathering and it should make a very satisfactory and attractive building stone.
Field Notes	this site has two quarries, one on the east side of M94 and one on the west side of M94. The deposit is layered, the layers are approximately 15 feet in depth. The west quarry already has the top 30 feet removed. It looks as though this stone is being quarried **for road aggregate only.**
Development Potential	Little Potential

Site # 40

Stone Type	Dolostone
Stone Description	blue grey to buff or tan in color
County	Delta
Site Location	NW ¼, SE ¼, Section 3, T40N, RI9W
Site Description	found in a pit located immediately adjacent to US 2

Historical Notes	Among the outcrop areas visited in Delta County, only two sites were considered suitable for use as dimension stone. Both deposits are dolostone. A pit, opened and operated by the Thornton Construction Company of Hancock, Michigan is located immediately adjacent to US 2 in the NW ¼ of the SE ¼ of Section 3, T40N, and RI9W. The quarry is in part of what is shown on the Michigan Geologic map as the Lower Silurian Mayville dolostone. The dolostone exposed in the quarry is fine-grained and is blue-gray to buff and tan in color. Beds are essentially flat lying and range from 2 ½ to 14 ½ inches thick though most are in the range 4½ to 9 inches. Nearly vertical major joints are spaced three or more feet apart and trend N48°W and W30°E. Joint surfaces weather tan and rust colored. Aside from carbonate
Field Notes	the quarry is currently operated part-time for road aggregate. The quarry is currently flooded with at few feet of water. The quarry face is approximately 10 to 12 feet high and is layered in 4 to 6 inch layers. The
Development Potential	Little Potential

Site # 41

Stone Type	Dolostone
Stone Description	white, blue-grey, tan and buff colors
County	Delta
Site Location	Section 24, T38N, RI9W
Site Description	found at top of high cliffs on shore of Lake Michigan (Roen's **Quarry)**
Historical Notes	This sample was collected from near the top of a high cliff exposure of the Silurian Burnt Bluff Group of carbonate rocks which crop out on the shore of Lake Michigan in Section 24, T38N, R19W. The stone has been worked here and the site is known as Roen's Quarry. However, no dimension stone has been produced. The beds are apparently flat lying and bedding plans spaced 2 inches to 4 feet apart. Texture is fine-grained, although some layers are vuggy in addition. Colors are white, blue-gray, tan, and buff. Widely spaced joints are nearly vertical and trend NW and NE. Under the microscope, the stone consists of finely crystalline carbonate with much of it in rhombic form. Scattered clastic quartz grains are present in layers parallel to bedding. The Sio2 content is 4.17% and MgO is 17.79%.
Field Notes	this site is located on high cliffs on the shore of Lake Michigan and is inaccessible.
Development Potential	No Potential

Site # 42

Stone Type	Epidotized Basalt
Stone Description	pale green and greenish yellow
County	Ontonogan
Site Location	SW ¼, Section 35, T51N, R38W
Site Description	accessible from Mass-Adventure road
Historical Notes	This specimen was collected from one of numerous poor rock piles located in the SW ¼ of Section 35, T51N, R38W. These poor rock piles are related to the Mass-Adventure group of mines and are readily accessible from the Mass-Greenland road. Large quantities of this pale green and greenish yellow amygdaloidal basalt may be procured from these mine dumps. The original basalt has been replaced by epidote and lesser amounts of white calcite. Although it probably would find common use as precast concrete panel aggregate, it could also be used in field stone type masonry work.
Field Notes	this site is located in the back western corner of the town of Greenland. All the outcroppings and quarry faces look to be very seamy in all directions. The site is poorly located.

Development Potential	No Potential

Site # 43

Stone Type	Altered Rhyolite
Stone Description	yellow green and olive green (may have bluish covering of copper
County	Ontonogan
Site Location	NE ¼, Section 6, T48N, R42W
Site Description	found in road metal quarry located on north side of M28, 1.2 miles west of its intersection with M64 at Bergland
Historical Notes	This material comes from a former road metal quarry located on the north side of M28, 1.2 miles west of its intersection with M64 at Bergland. It is in the NE ¼ of Section 6, T48N, R42W. A northerly trending shear zone in the face and floor of the quarry has been hydrothermally altered and mineralized over a width of about fifty feet. As a result of this alteration, the rhyolite is stained various shades of yellow green and olive green. Some surfaces are coated with a thin film of blue or bluish green copper carbonate. Minerals identified in thin sections include feldspar, quartz, sericite, carbonate, and iron oxide. This attractive rock could be used for field stone type masonry or, after crushing and screening, as precast concrete panel aggregate.
Field Notes	this site is located west of the town of Bergland on the north side of M28. The quarry face is 100 feet from M28, the railroad is 300 feet away, and Lake Gogebic is 400 feet away. Several homes and a hotel are in close proximity. The deposit appears to have many seams. The colors are
Development Potential	No Potential

Site # 44

Stone Type	Banded Rhyolite
Stone Description	pink to pinkish brown and orange
County	Ontonogan
Site Location	NE ¼, Section 6, T48N, R42W
Site Description	found in road metal quarry located on north side of M28, 1.2 miles west of its intersection with M64 at Bergland- found in road metal quarry located on north side of M28, 1.2 miles west of its intersection with M64 at Bergland
Historical Notes	Sample #44 is from the same quarry as sample #43. The stone is unaltered and ranges in color from pink to pinkish brown and orange. Some of the rhyolite is banded. Both banded and massive varieties are fine-grained. Quartz, feldspar, and iron oxide are the common minerals. Many directions of jointing are present and certainly this limits the use of the stone to aggregate. More detail concerning the rhyolite in this quarry is available in the M.S. thesis of R.W. Leonardson on file at the Library at Michigan Technological University. Field Notes this site is located west of the town of Bergland on the north side of M28. The quarry face is 100 feet from M28, the railroad is 300 feet away, and Lake Gogebic is 400 feet away. Several homes and a hotel are in close proximity. The deposit appears to have many seams. The colors are
Development Potential	No Potential

Site # 45

Stone Type	Amygdaloidal Basalt
Stone Description	dark purplish red with orange, red, white, and green spots
County	Ontonogan
Site Location	SE ¼, Section 15 and SW ¼, Section 14, T50N, R39W
Site Description	found in rock piles of Minnesota Mine
Historical Notes	Poor rock piles of the Minnesota Mine in the SE ¼ of Section 15 and SW ¼ of Section 14, T50N, R39W provides the samples of this stone. These mine dumps are extensive and much of this unusual stone could be hand-picked from them. The rock is a dark purplish red, fine-grained basalt with many orange, red, white, and green spots scattered throughout. Plagioclase feldspar and altered pyroxene are the major minerals. The "spots" are actually gas cavity fillings of orange-red adularia (a feldspar), quartz, green epidote, and carbonate. This unusual stone could be cut and polished for paperweights and pen sets, crushed for panel aggregate, or used in masonry work.
Field Notes	this site is located north of the railroad and south of M45. The deposit is very fragmented and would not be suitable for dimension stone.
Development Potential	No Potential

Site # 46

Stone Type	Beach Cobbles
Stone Description	
County	Chippewa
Site Location	Sections 3 and 4, T50N, R7W
Site Description	found along shore of Lake Superior
Historical Notes	An interesting deposit of flat rounded cobbles occurs on the shore of Lake Superior in Sections 3 and 4 of T50N, R7W. These cobbles are almost always elliptical in shape and range from 3 to 5 inches on the long axis and are from an inch to one and one half inches thick. Most common rock types are granite, granitic gneiss, basalt, and diabase. Tan sandstone cobbles are present but not common. Thin sections of these representative rock types show that all are fresh and unweathered. This deposit is extensive and is constantly being increased in size by onshore movement of cobbles during storms on the lake. The attractive shapes and color variations make this material desirable for use as a surfacing for precast concrete panels and it has been used for this purpose in at least one structure.
Field Notes	Not a consideration for dimension stone.
Development Potential	No Potential

Site # 47

Stone Type	Dolostone
Stone Description	near white to tan and buff colors
County	Chippewa
Site Location	Section 23, T42N, R5E
Site Description	found in Somes Quarry

Historical Notes	This sample came from Somes Quarry located in Section 23, T42N, R53E. The quarry is operated intermittently for dimension stone. A twenty-foot thickness in the quarry displays beds 1 to 3 feet thick dipping up to 5°S. Vertical joints spaced 1 to 6 feet apart have trends ofN47°E and N45°W. Colors range from near white to tan and buff and the rock is very fine grained. Under microscope, a thin section shows that the dolomite contains a few quartz grains and a little iron staining in addition to the carbonate. The chemical analysis gives Si02 at 3.31% and MgC03 about 42%. Many local buildings have been constructed of this stone and it is evidently very durable. It weathers to gray and chalk-white.
Field Notes	Not Available.
Development Potential	No Potential

Site # 52

Stone Type	Sandstone
Stone Description	Not Available.
County	Alger
Site Location	Location on Sand Point Section 19,T47N, RI8W
Site Description	Not Available.
Historical Notes	Not Available.
Field Notes	Not Available.
Development Potential	No Potential

Site # 53

Stone Type	Sandstone
Stone Description	Not Available.
County	Alger
Site Location	Section 28, T47 N, R 19 W
Site Description	Abandoned quarry located along shore east of Bay Furnace and west of east line of Section 28
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	No Potential

Site # 54

Stone Type	Sandstone
Stone Description	Not Available
County	Alger
Site Location	Section 25-26, T 48 N, R 22 W
Site Description	Abandoned quarry located on Laughing Fish Point
Historical Notes	Not Available.
Field Notes	None Available.

Development Potential	No Potentia

Site # 55

Stone Type	Sandstone
Stone Description	Not Available.
County	Alger
Site Location	Section 34, T 47 N, Section 26, T48 N, R 22 W
Site Description	Abandoned quarry located along the Laughing White Fish River below Laughing White Fish Lake
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	No Potential

Site # 56

Stone Type	Sandstone
Stone Description	Not Available.
County	Alger
Site Location	8, 26, 27, T47N, R 19W
Site Description	Abandoned quarries located on Powell (Paul's) Point
Historical Notes	Not Available.
Field Notes	None Available
Development Potential	. Little Potential

Site # 57

Stone Type	Sandstone
Stone Description	Not Available.
County	Alger
Site Location	SE ¼, SIS, T47N, RI9W
Site Description	Abandoned quarry located on southwest end of Grand Island Bay
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 58

Stone Type	Sandstone
Stone Description	Not Available.
County	Alger

Site Location	Section I5, T47N, R21W
Site Description	Used to be Rock River Brownstone Company
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 59

Stone Type	Sandstone
Stone Description	Not Available.
County	Baraga
Site Location	SW, Section 25, T 51 N, R33 W
Site Description	Used to be L'Anse Brownstone Company Quarry
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 60

Stone Type	Sandstone
Stone Description	Not Available.
County	Baraga
Site Location	NE .Section 2, T52N, R33W
Site Description	Used to be Superior Red Sandstone Company Quarry
Historical Notes	Not Available
Field Notes	None Available.
Development Potential	Little Potential

Site # 61

Stone Type	Sandstone
Stone Description	Not Available.
County	Chippewa
Site Location	NE, SE, Section 36, T 48N, R 2 E
Site Description	Abandoned quarry located on Sugar Island near Churches **Landing.**
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	No Potential

Site # 62

Stone Type	Sandstone
Stone Description	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
County	Houghton
Site Location	NE, Section 24, T 53 N, R33 W
Site Description	Used to be Michigan Redstone Company
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 63

Stone Type	Sandstone
Stone Description	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
County	Houghton
Site Location	NE .SW . Section 8, T 53N, R32 W
Site Description	Stone Quarry Lake
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 64

Stone Type	Sandstone
Stone Description	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
County	Houghton
Site Location	Section 24 & 25, T 53 N, R 33W
Site Description	Abandoned quarries (along Keweenaw Bay)
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 65

Stone Type	Sandstone
Stone Description	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
County	Houghton

Site Location	NE,Section 19, T 53 N, R32 W
Site Description	Used to be Kerber-Jacobs Redstone Co.
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 66

Stone Type	Sandstone
Stone Description	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
County	Houghton
Site Location	Section 31 or 32, T 55 N, R 33W
Site Description	Abandoned quarry located at head of Portage Lake probably somewhere from this point to Hancock and on the north or Hancock side of the Portage
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 67

Stone Type	Sandstone
Stone Description	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
County	Houghton
Site Location	"Lot 1" ofSECTION 19, T53N, R32W
Site Description	Used to be Wolf and Jacobs Company located at Portage Entry
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 68

Stone Type	Sandstone
Stone Description	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
County	Houghton
Site Location	Section 18, T53N, R32W Also Section 13, 18, 19
Site Description	Numerous abandoned quarries formerly run by the Portage Entry **Quarries Company**
Historical Notes	Not Available.
Field Notes	None Available.

Development Potential	Little Potential

Site # 69

Stone Type	Sandstone
Stone Description	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
County	Houghton
Site Location	Section 8, T53N, R32W
Site Description	Abandoned quarry located on the Keweenaw Bay (Kerber-Jacobs **Redstone Company)**
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 70

Stone Type	Sandstone
Stone Description	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
County	Houghton
Site Location	Section 8, T53N, R32W
Site Description	Abandoned quarry located two miles inland from Red Rock **(Excelsior Red Stone Company)**
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	Little Potential

Site # 71

Stone Type	Sandstone
Stone Description	The sandstone in this area ranges from red to red and white variegated to brownish red. The color and texture of the stone will vary with location and with depth.
County	Houghton
Site Location	Lot3, Section 19, T53N, R32W
Site Description	Abandoned quarry located near Portage Entry, adjoining government lighthouse reservation (Lake Superior Redstone Company)
Historical Notes	Not Available.
Field Notes	None Available
Development Potential	Little Potential

Site # 72

Stone Type	Sandstone
Stone Description	reddish brown colored sandstone with a consistent fine-grained texture
County	Houghton
Site Location	Section 1, T55N, R33W- East Center of Section 1
Site Description	Quarry located just west of Lake Linden
Historical Notes	Not Available.
Field Notes	Formally excellent quarry site- filled with water- however, excellent ridge running in a northerly direction NNE by SSW - plenty of land for exploration.
Development Potential	Good Potential

Site # 73

Stone Type	Sandstone
Stone Description	Not Available.
County	Keweenaw
Site Location	NE, NW ¼, NW ¼, Section 6, T56N, R 31W
Site Description	Abandoned quarry of Traverse Bay Redstone Co.
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	No Potential

Site # 74

Stone Type	Sandstone
Stone Description	Not Available.
County	Keweenaw
Site Location	Section 6, T56N, R31W
Site Description	Abandoned quarry run by the Portage Entry Quarries Company
Historical Notes	Not Available.
Field Notes	None Available
Development Potential	No Potential

Site # 75

Stone Type	Sandstone
Stone Description	Not Available.
County	Marquette
Site Location	E ½, Section 23, T 48 N, R 25W
Site Description	Abandoned quarry (valley close to road)

Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	No Potential

Site # 76

Stone Type	Sandstone
Stone Description	Not Available
County	Marquette
Site Location	Section 24, T 48 N, R 25 W
Site Description	Abandoned quarry located slightly west of Lighthouse Point at **Marquette**
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	No Potential

Site # 77

Stone Type	Sandstone
Stone Description	Not Available.
County	Marquette
Site Location	Section 26, T48N, R25W South Marquette
Site Description	Not Available.
Historical Notes	Not Available.
Field Notes	None Available.
Development Potential	No Potential

Site # 78

Stone Type	Sandstone
Stone Description	Not Available.
County	Marquette
Site Location	835, T48N, R25W
Site Description	Mount Mesnard -- found off of M28 on Cliff Power Road. Go south to the river, continue on to the end of the road. On the right over to the west will be a gated road to Mt. Marquette road.
Historical Notes	Not Available.
Field Notes	It appears to me to be a very old quarry site. There are slight drill markings on the east side wall of this deposit. The mineral varies in color from purplish-pink to beige with large round spots in it. This site is very secluded for being in the city limits of Marquette. There are no utilities in the area the
Development Potential	No Potential

Site # 79

Stone Type	Sandstone
Stone Description	Not Available.
County	Marquette
Site Location	Section 30, T52N, R27W
Site Description	Mouth of Salmon Trout River
Historical Notes	Not Available. (see Report of Investigation 28 / Eagle mine)
Field Notes	None Available.
Development Potential	No Potential

Site # 80

Stone Type	Sandstone
Stone Description	Not Available.
County	Marquette
Site Location	Section 35, T50N, R26W
Site Description	Thoney's Point
Historical Notes	None
Field Notes	Not Available.
Development Potential	No Potential

Site # 81

Stone Type	Slate
Stone Description	Dark colored slate.
County	Baraga
Site Location	Section 29, T5lN, R31W
Site Description	Not Available.
Historical Notes	Not Available.
Field Notes	Found north of L'Anse in Baraga County. Go north on Skanee Road to Arvon Road (there should be a little green sign there)-- if you cross the Slate River then you have gone too far. Go east on Arvon Road for about 4 miles. You will come to a 90° turn -- take the turn, don't go straight. You will come to another 90° turn go straight, don't turn. The quarry should be straight ahead -- stay on the right hand side of the road, there are big potholes on the left.
Development Potential	Little Potential

Site # 82

Stone Type	Granite
Stone Description	The stone is pink and grey in color
County	Marquette

Site Location	SE ¼ Section 14 T47N R29W
Site Description	According to the Callahan map, this deposit is younger than the surrounding rock, so it is probably less disturbed and fractured.
Historical Notes	Not Available.
Field Notes	It is the first creek crossing, 2 miles south of Humboldt Mine on Route 601. It is found in a road cut. There are 2 trailer homes across the street they are not year round homes. The deposit appears small, but the grain appears to
Development Potential	Little Potential

Site # 83

Stone Type	Granite
Stone Description	pinkish, greyish color good grain.
County	Marquette
Site Location	SW ¼Section 22 T47N R29W
Site Description	According to the Callahan map, this deposit is younger than the surrounding rock, so it is probably less disturbed and fractured.
Historical Notes	Not Available.
Field Notes	Located 3.5 miles south of Humboldt Mine on Route 601 at the first sharp curve. The deposit is very large. The stone appears to be the same as the previous Site #82.
Development Potential	Little Potential

Site # 84

Stone Type Sandstone	Sandstone
Stone Description	Red and white Sandstone
County	Alger
Site Location	SE Section 8 T47N R21W
Site Description	Found on an outcropping on M28 and Shelter Bay Road, approx. 30 miles east of Marquette. Historical Notes Not Available. Field Notes Not Available Development Potential No Potential

Site # 85

Stone Type	Not Available
Stone Description	Not Available
County	Delta
Site Location	T41N Rl8W or T40N Rl9W
Site Description	Found in quarry located right off of US 2 near Isabella
Historical Notes	Not Available.
Field Notes	Not Available.
Development Potential	No Potential

Site # 86

Stone Type	Limestone
Stone Description	Not Available.
County	Delta
Site Location	
Site Description	Found in quarry located approx. 8 miles south of US 2 near town of **Ensign**
Historical Notes	Not Available.
Field Notes	Not Available.
Development Potential	No Potential

Site # 87

Stone Type	Siliceous Limestone
Stone Description	white color
County	Marquette
Site Location	Section 12 T42N R26W found north of Arnold
Site Description	Not Available.
Historical Notes	Not Available.
Field Notes	Not Available.
Development Potential	No Potential

Site # 88

Stone Type	Limestone
Stone Description	Not Available.
County	Schoolcraft
Site Location	Section 35 T42N RI4W
Site Description	Inland Quarry, found off of US 2 in Gulliver
Historical Notes	Not Available.
Field Notes	Not Available.
Development Potential	No Potential

Site # 89

Stone Type	Sandstone
Stone Description	Not Available.
County	Dickinson
Site Location	Section 32, 33 T42N R28W
Site Description	found in road cut along M69, near Felch
Historical Notes	Not Available.

Field Notes	Not Available.
Development Potential	No Potential

Site # 90

Stone Type	Marble
Stone Description	white colored marble
County	Dickinson
Site Location	Section 34, 35 T42N R30W
Site Description	See Field Notes
Historical Notes	Not Available.
Field Notes	Take the road directly across from Webb's business, approximately 3/10 of a mile - there is a road going to the left - blacktop- on this corner lives Don Hamby- approximately 75 yrs. Old who ran or worked in all of the marble quarries in the area. We did not make contact with him. At this corner, traveling 3/10 of a mile, northerly, we encountered the first quarry, on the left-hand side- it was raining, so we did not enter, however, there were 6 or 8 large concrete pillars visible with past quarry activity to the north of these pillars - we understand this is on the same ridge as the subsequent marble
Development Potential	Little Potential

Site # 91

Stone Type	Marble
Stone Description	white colored marble
County	Dickinson
Site Location	Section 34, 35 T42N R30W
Site Description	Traveling 3/10 of a mile past the first site, was another former marble quarry (closed some 30-50 years). This one was cut into the mountain, approximately 100' wide- drilled & blasted- no recent activity.
Historical Notes	Not Available.
Field Notes	There were 6 or 8 large concrete pillars visible with past quarry activity to the north of these pillars.
Development Potential	Good Potential

Site # 92

Stone Type	Marble
Stone Description	white colored marble
County	Dickinson
Site Location	834,35 T42N R30W
Site Description	See Field notes.
Historical Notes	Not Available.
Field Notes	The major quarry in the area was located here. The site was nestled into the hills - several acres in size - now with water approximately 12' deep. This quarry has been closed 30-50 years.

Development Potential	Little Potential

Site # 93

Stone Type	Pegmatite
Stone Description	Pink to orange in color, some chips of mica present.
County	Dickinson
Site Location	Section 23 T42N R30W
Site Description	See field notes.
Historical Notes	Not Available.
Field Notes	From here we traveled again with Curt Sexton, back to Hwy. 95 and turned east on Hwy. 69 - traveled approximately 1 mile east, just before the river to the resident of Oren Fry - talked with him about the pink stone located north of his home - he said he did not own it - it belongs to champion. He said the original gate is right next door to his home - gate locked - only about Ya mile into the quarry, however, champion has put rocks across the road and you cannot get in that way. He also said that if we follow the river, which was a few hundred yards east of his house - going to the north, the quarry is only about 14 mi in that way. He gave us directions which added considerable mileage to get into the quarry- we went back to hwy. 95, and went north to the first red gate, which is always open. This was at least ¼ mile north - we followed this road in an easterly direction, using the following instructions: Go easterly to the first fork -bare right - continue on until the next fork in the road - again bare right - continue on until the next fork in the road - again bare right. Continue on until the next fork in the road - at this point, take a left and continue on until you reach the quarry - it is well-defined - you can drive right into the quarry - it is right next to the sturgeon river has a good supply of pegmatite - a pinkish stone - very attractive - however, flakes of mica are present which peel- may be difficult for dimension stone. The face is well-defined- top of the quarry has few fractures and would have good stone.
Development Potential	Little Potential

Site # 94

Stone Type	Sandstone
Stone Description	reddish white color
County	Alger
Site Location	Section 11 T47N R20W
Site Description	Not Available
Historical Notes	Not Available.
Field Notes	On M28, in Christmas, turn north on Reindeer Road. Near the end of the road at S-Mile Point, there is a road/trail that goes across Section 13 and 14. This road goes to the shoreline in Section 11
Development Potential	No Potential

Site # 95

Stone Type	Sandstone
Stone Description	light purple/white color
County	Alger
Site Location	SW ¼NE ¼Section 29 T47N R21W

Site Description	Not Available.
Historical Notes	Not Available.
Field Notes	Go south on HO1 from new M28 to old M28. After crossing the railroad tracks, go west for a few hundred yards. Approx. 1.2 miles south of this intersection is a road that goes to the west into Section 33, from there one must walk as the road is blocked - approx. ½ mile in a NNW direction, down through a gully on the eastern edge of low cliffs.
Development Potential	No Potential

Site # 96

Stone Type	Syenite Porphyry
Stone Description	large grained, pink and black colored stone
County	Marquette
Site Location	Section 17 T48N R26W
Site Description	Found North of Negaunee -- take Baldwin road north to Negaunee Rod and Gun Club. Take the road to the east of Baldwin Road approximately 1-1 ¼miles. Go north across power line and ridge will be running east and west.
Historical Notes	Not Available.
Field Notes	This site is most interesting in the fact that the stone contains no silica and is softer than most granites, which will make the stone easier to cut. On the surface it appears that there is a large deposit. The stone should have a good potential in the marketplace because of its unique characteristics and
Development Potential	Good Potential

Site # 97

Stone Type	Bell Creek Gneiss
Stone Description	stone samples collected are a very bright red with quartz phenocrysts dispersed throughout
County	Marquette
Site Location	SE ¼ Section 29 T47N R28W
Site Description	Found south of Greenwood Reservoir
Historical Notes	Not Available
Field Notes	This site is virtually on Highway 478, just south of the Greenwood Reservoir. This is a very interesting site as the stone is quite contiguous and easily accessible. There are fractures present which only core drilling will determine how deep they are.
Development Potential	Good Potential

APPENDIX H - Glossary of Stone Terms

(from the Stone World 1998 Buyers Guide, pp. 77-106)

A

ABRASIVE FINISH: a flat non-reflective surface finish for marble.

ABUTMENT: a solid stone "springer" at the lowest point of an arch or vault.

ADHERED: veneer secured and supported through adhesion to an approved bonding material applied over an approved backing

AGATE: a variegated variety of quartz showing colored bands or other markings (clouded, moss-like, etc.).

ANCHORS: types for stonework include those made of flat stock (strap, cramps, dovetails, dowel, strap and dowel, and two-way anchors) and round stock (rod cramp, rod anchor, eyebolt and dowel, flat-hood wall tie and dowel, dowel and wire toggle bolts).

ARCH: a curved stone structure resting on supports at both extremities used to sustain weight, to bridge or roof an open space.

ARCHITRAVE: the member of an entablature resting on the capitals of columns and supporting the frieze.

ARGILLITE: a compact sedimentary rock composed mainly of clay and aluminum silicate minerals

ARKOSE: a sandstone containing 10% or more clastic grains of feldspar. Also called arkosic sandstone, feldspathic sandstone.

ARRIS: a natural or applied line on the stone from which all leveling and plumbing is measured.

ASHLAR: masonry having a face of square or rectangular stones, either smooth or textured.

B

BACK ARCH: a concealed arch carrying the backing of a wall where the exterior facing is carried by a lintel.

BALUSTER: a miniature pillar or column supporting a rail, used in balustrades.

BASALT: a dense-textured (aphanitic) igneous rock relatively high in iron and magnesia minerals and relatively low in silica, generally dark grey to black, and feldspathic; a general term in contradistinction to felsite, a light-colored feldspathic and highly siliceous rock of similar texture and origin.

BED: the top or bottom of a joint, natural bed; surface of stone parallel to its stratification. (1) in granites and marbles, a layer or sheet of the rock mass that is horizontal, commonly curved and lenticular, as developed by fractures. Sometimes applied also to the surface of parting between sheets. (2) In stratified rocks the unit layer formed by sedimentation; of variable thickness, and commonly tilted or distorted by subsequent deformation; generally develops a rock cleavage, parting, or jointing along the planes of stratification.

BELT COURSE: a continuous horizontal course of flat stones placed in line marking a division in the wall plane.

BEVEL: when the angle between two sides is greater or less than a right angle.

BLUESTONE: a dense, hard, fine-grained, commonly feldspathic sandstone or siltstone of medium to dark or bluish-grey color that splits readily along original bedding planes to form thin slabs. Bluestone is not a technical geological term. It is considered to be a variety of flagstone, the thin relatively smooth-surfaced slabs being suitable for use as flagging. The term has been applied particularly to sandstones of Devonian age that are being or have been quarried in eastern New York and Pennsylvania and in western New Jersey, but similar stones that occur elsewhere may be included. It has also been applied in places to thinly-layered gneisses and schists that can be slit and used as flagging, but such stones are not properly embraced by this definition, although they may be marketed properly as flagstone.

BOND STONE: used in varying percentages to anchor or bond the stone veneer to the backing material. Bond stones are generally cut twice the bed thickness of the material being used.

BORDER STONE: usually a flat stone used as an edging material. A border stone is generally used to retain the field of the terrace or platform.

BOX: a tapered metal box wedged in the top of columns or other heavy stones for hoisting

BROACH: to drill or cut out material left between closely spaced drill holes; a mason's sharp-pointed chisel for dressing stone; an inclined piece of masonry filling the triangular space between the base of an octagonal spire and the top of a square tower; a type of chisel used for working narrow surfaces.

BROWNSTONE: a sandstone of characteristic brown or reddish-brown color that is due to a prominent amount of iron-oxide, as interstitial material.

BRUSHED FINISH: Obtained by brushing the stone with a coarse rotary-type wire brush.

BUILDING STONE, NATURAL: rock material in its natural state of composition and aggregation as it exists in the quarry and is usable in construction as dimension building stone.

BULL NOSE: convex rounding of a stone member, such as a stair tread.

C

CALCARENITE: limestone composed predominately of clastic sand-size grains of calcite, or rarely aragonite, usually as fragments of shells or other skeletal structures. Some calcarenites contain oolites (small, spherical grains of calcium carbonate that resemble roe) and may be termed oolitic limestone. Calcareous sandstones, in which the calcium carbonate is present chiefly as bonding material, are not included in this category.

CALCITE LIMESTONE: a limestone containing not more than S% of magnesium carbonate.

CALCITE STREAKS: description of a white or milky-like streak occurring in stone.

It is a joint plane usually wider than glass seam and has been re-cemented by deposition of calcite in the crack and is structurally sound.

CANOPY: a sheltering roof, as over a niche or a doorway.

CAPITAL: the culminating stone at the top of a column or pilaster, often richly carved.

CARVE: shaping, by cutting a design to form the trade of a sculptor.

CAULKING: making a marble joint tight or leak-proof by sealing with an elastic adhesive compound.

CAVITY VENT: an opening in joints or masonry to allow the passage of air and moisture from the wall cavity to the exterior.

CEMENT PUTTY: a thick, creamy mixture made with pure cement and water which is used to strengthen the bond between the stone and the setting bed. Also called cement butter, cement cream.

CHAMFER: to bevel the junction of an exterior angle.

CHAT-SAW FINISH: a rough gangsaw finish produced by sawing with coarse chat.

CLADDING: non-loadbearing stone used as the facing material in wall construction that contains other materials.

CLEAVAGE: the ability of a rock mass to break along natural surfaces; a surface of natural parting.

CLEAVAGE PLANE: plane or planes along which a stone may likely break or delaminate

COATING: a protective or decorative covering applied to the surface or impregnated into stone for such purposes as waterproofing, enhancing resistance to weathering, wear, and chemical action, or improving appearance of the stone.

COBBLESTONE: a natural rounded stone, large enough for use in paving; commonly used to describe paving blocks, usually granite, generally cut to rectangular shapes.

COMMERCIAL MARBLE: a crystalline rock composed predominantly of calcite dolomite and/or serpentine, and capable of taking a polish.

COMPOSITE: a construction unit in which stone that is to be exposed in the final use is permanently bonded or joined to other material, which may be stone or manufactured material, that will be concealed.

CONTRACTION JOINTS: spaces where panels are joined and which expand as the panels contract.

CONTROL JOINT: provision for the dimensional change of different parts of a structure due to shrinkage, expansion, temperature variation or other causes so as to avoid the development of high stresses.

COPING: a flat stone used as a cap on freestanding walls.

COQUINA: a limestone composed predominantly of unaltered shells or fragments of shells loosely cemented by calcite, generally very coarse-textured with a high porosity. The term has been applies principally to a very porous shell rock of Eocene age that has been quarried in Florida.

CORBEL PLATES: plates of non-ferrous metal fixed into a structure to support stone cladding at intervals and over openings in such a way as not to be visible.

CORNERSTONE: a stone forming a part of a corner or angle in a wall. Also a stone laid at the formal inauguration of the erection of a building, not necessarily at a corner, usually incorporating a date or inscription.

CORNICE: a molded projecting stone at the top of an entablature.

COURSE: a horizontal range of stone units the length of the wall.

COURSED VENEER: this is achieved by using stones of the same or approximately the same heights. Horizontal joints run the entire length of the veneered area.

Vertical joints are constantly broken so that no two joints will be over one another.

CRACK: a break, split, fracture, fissure, separation, cleavage, or elongated narrow opening, however caused, visible without magnification to the human eye and extending from the surface into the stone, that must extend through the grain or matrix.

CROSS-BEDDING: the arrangement of laminations of strata transverse or oblique to the main planes of stratification.

CROWFOOT (STYOLITE): description of a dark grey to black zigzag marking occurring in stone. Usually structurally sound.

CRYSTALLINE LIMESTONE: a limestone, either calcitic or dolomitic, composed of interlocking crystalline grains of the constituent minerals and of phaneritic texture; commonly used synonymously with marble and thus representing a recrystallized limestone; improperly applied to limestones that display some obviously crystalline grains in a fine-grained mass but which are not of interlocking texture and do not compose the entire mass. (NOTE: All limestones are microscopically, or in part megascopically, crystalline; the term is thus confusing but should be restricted to stones that are completely crystalline and of megascopic and interlocking texture and that may be classed as marbles.)

CURBING: slabs and blocks of stone bordering streets, walks, etc.

CUT STONE: stone fabricated to specific dimensions.

CUTTING STOCK: a term used to describe slabs of varying size, finish, and thickness which are used in fabricating treads, risers, copings, borders, sills, stools, hearths, mantels, and other special purpose stones.

D

DACITE: a fine-grained, extrusive (volcanic) rock, intermediate in color and composition between basalt and rhyolite.

DAMP-PROOFING: one or more coatings of a compound that is impervious to water applied to a surface above grade.

DEFECT: those features which affect or have the potential of affecting the structural soundness of building stone, or may affect the durability of the building stone.

Sometimes used for visual features such as xenoliths or veins.

DENTIL: block projections on an entablature.

DENTIL COURSE: the lower part of the cornice with dentils. The cornice is jointed to allow machine production of the dentils.

DENTILS: small, rectangular blocks under a classical cornice, resembling a row or teeth.

DIMENSION STONE: natural building stone that has been selected, trimmed or cut to specified or indicated shapes or sizes with or without one or more mechanically dressed surfaces.

DOLOMITIC LIMESTONE: a limestone rich in magnesium carbonate, frequently somewhat crystalline in character, found in ledge formations in a wide variety of color tones and textures. Generally speaking, its crushing and tensile strengths are greater than the oolitic limestones and its appearance shows greater variety in texture.

DOWEL: a short piece of non-ferrous metal or slate fixed into a mortice or sinking in the joints of adjoining stones to prevent movement.

DRESSED OR BAND-DRESSED: the cutting of rough chunks of stone by hand to create a square or rectangular shape. A stone which is sold as dressed stone generally refers to stone ready for installation. Sometimes called scabbling.

DRIP: a recess cut under a sill or projecting stone to throw off water, preventing it from running down the face of the wall or other surface, such as a window or door.

DRIPSTONE: a projecting molding over the heads of doorways, windows and archways to throw off the rain. Also known as a "hoodmould" and, when rectangular, as a "label".

DRY: an open or unhealed joint plane not filled with calcite and not structurally sound.

DRY WALL: a dry wall is a stone wall that is constructed one stone upon the other without the use of any other mortar. Generally used for retaining walls.

DURABILITY: the measure of the ability of natural building stone to endure and to maintain its essential and distinctive characteristics of strength, resistance to decay, and appearance, with relation to a specific manner, purpose, and environment of use.

E

EFFLORESCENCE: a crystalline deposit appearing on stone surfaces typically caused by soluble salts carried through or onto the stone by moisture, which has *http:/ /www.deq.state.mi. us/gsd/DSFS/DSFSReport.pdf* Page 171 sometimes been found to come from brick, tile, concrete blocks, cement, mortar, concrete, and similar materials in the wall or above.

ENTABLATURE: in classical architecture, the upper part of an order, comprising architrave, frieze, and cornice.

ENTASIS: the curve of the upper two-thirds of a column.

EXPANSION BOLT: a socket that grips a drilled hole in stone by expanding as the bolt is screwed into it.

EXPANSION-CONTRACTION JOINT: a joint between marble units designed to expand or contract with temperature changes. An expansion joint compresses as panels expand.

EXPOSED AGGREGATE: phrase applied to the larger pieces of stone aggregate purposefully exposed for their color and texture in a cast slab.

F

FACE: this refers to the exposed portion of stone. The word "face" can also be sued when referring to the edge treatment on various cutting stock materials.

FASCIA: a horizontal belt or vertical face; often used in combination with moldings.

FERRUGINOUS: limestone or sandstone containing a high proportion of iron oxide.

FIELD STONE: loose blocks separated from ledges by natural processes and scattered through or upon the regolith ("soil") cover; applied also to similar transported materials, such as glacial boulders and cobbles.

FILLING: a trade expression used in the fabrication of marble to indicate the filling of natural voids with cements, shellac or synthetic resins and similar materials.

FINES: the powder, dust, silt-size and sand-size material resulting from processing (usually crushing) rock.

FINISH: final surface applied to the face of stone during fabrication.

FINISHED STONE: building stone with one or more mechanically dressed surface(s).

FIREPROOF: relatively incombustible.

FLAGSTONE: thin slabs of stone used for flagging or paving walks, driveways, patios, etc. It is generally fine-grained sandstone, bluestone, quartzite or slate, but thin slabs of other stones may be used.

FLEURI CUT: cutting quarried marble or stone parallel to the natural bedding plane.

FLOORING: stone used as an interior pedestrian wearing surface.

FRACTURE: a break in rock produced by mechanical failure. Fractures include faults and joints.

FREESTONE: a stone that may be cut freely in any direction without fracture or splitting.

FRIEZE: a belt course, sometimes decorated with sculpture relief, occurring just under a cornice.

G

GANGSAWED: description of the granular surface of stone resulting from gangsawing alone.

GAUGED OR GAUGING: a grinding process to make all pieces of material to be used together the same thickness.

GLASS SEAM: description of a narrow glass-like streak occurring in stone; a joint plane that has been re-cemented by deposition of translucent calcite in the crack and structurally sound.

GRADE COURSE: beginning course at the grade level, generally waterproofed with a dampcheck or damp course.

GRAIN: the easiest cleavage direction in a stone. "With the grain" same as "natural bed." Also, particles (crystals, sand grains, etc.) of a rock.

GRANITE: a fine to coarse-grained, igneous rock formed by volcanic action consisting of quartz, feldspar, and mica, with accessory minerals. Granite-type rocks include those of similar texture and origin.

GRANITE (SCIENTIFIC DEFINITION): a visibly granular, crystalline rock of predominantly interlocking texture, composed essentially of alkalic feldspars and quartz; this is true granite. Feldspar is generally present in excess of quartz, and accessory minerals (chiefly micas, hornblende, or more rarely pyroxene) are commonly present. The alkalic feldspars may be present (1) as individual mineral species, (2) as isomorphous or mechanical intergrowths with each other, or (3) as chemical intergrowths with the lime feldspar molecule, but 80 + 3 per cent of the feldspar must be composed of the potash or soda feldspar molecules.

GRANITE (COMMERCIAL/BUILDING USE): a term that includes granite (as defined above), gneiss, gneissic granite, granite gneiss, and the rock species known http:/ /www.deq.state.mi. us/gsd/DSFS/DSFSReport.pdf Page 173 to petrologists as syenite, monzonite, and granodiorite, species intermediate between them, the gneissic varieties and gneisses of corresponding mineralogic compositions and the corresponding varieties of porphyritic textures. The term commercial granite shall also include other feldspathic crystalline rocks of similar textures, containing minor amounts of accessory minerals, used for special decorative purpose, and known to petrologists as anorthosite and laurvikite.

- ***-- GRANITE GNEISS:*** a foliated crystalline rock composed essentially of silicate minerals with interlocking and visibly granular texture, and in which the foliation is due primarily to alternating layers, regular or irregular, of contrasting mineralogic composition. In general, a gneiss is characterized by relatively thick layers as compared with a schist. According to their mineralogic compositions, gneisses may correspond to other rocks of crystalline, visibly granular, interlocking texture, such as those included under the definition of commercial granite, and may then be known as granite gneiss if strongly foliated, or gneissic granite if weakly foliated.
- ***-- BLACK GRANITE:*** rock species known to petrologists as diabase, diorite, gabbro, and intermediate varieties are sometimes quarried as building stone, chiefly for ornamental use, and sold as "black granite." As dimension blocks or slabs, they are valued specifically for their dark grey to black color when polished. Scientifically, they are far removed in composition from true granites though they may be satisfactorily used for some of the purposes to which commercial granites are adapted. They possess an interlocking crystalline texture, but unlike granites, they contain little or no quartz or alkalic feldspar, and are characterized by an abundance of one or more of the common black rock-forming minerals (chiefly pyroxenes, hornblende, and biotite).

GRANULAR: having a texture characterized by particles that are apparent to the unaided eye. For sedimentary rocks: particles less than 4 inches (10 mm) in diameter and approximately equal in size.

GREENSTONE: includes stones that have been metamorphosed or otherwise changed so that they have assumed a distinctive greenish color owing to the presence of one or more of the following minerals: chlorite, epidote, or actinolite.

Greenstone is an old field term applied to metamorphosed igneous rock of mafic of ultramafic (low silica) composition (i.e., basalt, diabase, gabbro, peridotite, and serpentinite). Greenstone derived from basalt and other dark volcanic rocks consists dominantly of epidote, actinolite and plagioclase. No present commercial production of such rocks is known. Peridotite consists dominantly of olivine and pyroxene. Serpentinite consists largely or talc, chlorite, and serpentine; further alteration may result in soapstone.

GROUT: mortar of pouring consistency. Coarse grout, used for wide grout spaces 2 inches (S em) or more, consists of one part portland cement, not more than two to three parts sand, and not more than two parts pea gravel. Fine grout, used in narrow *http:/ /www.deq.state.mi. us/gsd/DSFS/DSFSReport.pdf* Page 174 grout spaces, consists of one part portland cement and two-and-one quarter to three parts sand.

H

HAND-CUT RANDOM RECTANGULAR .ASHLAR: a pattern where all the stone is hand cut into squares and rectangulars. Joints are fairly consistent. Similar to sawed-bed ashlar in appearance.

HAND OR MACHINE PITCH-FACED (ROCK-FACED) .ASHLAR: a finish given to both veneer stone and cutting stock. This is created by establishing a straight line back from the irregular face of the stone. Proper tools are then used to cut along the line, leaving a straight arris and the intended rustic finish on the face.

HEAD: the end of a stone which has been tooled to match the face of the stone.

Heads are used at outside corners, windows, door jambs, or any place where the veneering will be visible from the side.

HEARTH: that part of the floor of a fireplace of stone on which the fire is laid.

HEARTH STONE: originally the single large stone or stones used for the hearth, now most commonly used to describe the stone in front of the fire chamber and many times extending on either or both sides of the front of the fire chamber.

HOLES: sinkages in the top beds of stones to engage Lewis pins for hoisting.

HONED FINISH: honed is a super fine smooth finish, though not as fine as a polished finish.

I

IGNEOUS: one of the three great classes of rock (igneous, sedimentary, and metamorphic), solidified from molten state, as granite and lavas.

INCISE: to cut inwardly or engrave, as in an inscription.

INSCRIPTION: lettering cut in stone.

J

JACK .ARCH: one having horizontal or nearly horizontal upper and lower surfaces.

Also called flat or straight arch.

JOINT: the space between stone units, usually filled with mortar.

JOINTING SCHEME: architects drawing detailing dimensions, location and configuration of marble units and joints as related to the structure.

JUMPER: in ashlar patterns, a piece of stone of higher rise than adjacent stones which is used to end a horizontal mortar joint at the point where it is set.

K

KEYSTONE: the last wedge-shaped stone placed in the crown of an arch regarded as binding the whole.

L

LAVA: a general term applied to igneous rocks, such as basalt and rhyolite, that erupted from the earth by volcanic action.

LEAD BUTTONS: lead spacers in the solid horizontal joints to support the top stones until the mortar has set.

LEWIS BOLES: holes in cut stones for lifting and support during setting of cut stones and sometimes for permanent support. Holes are checked for the particular Lewis lifting device or hook to be used.

LIMESTONE: a sedimentary rock composed of calcium carbonate; includes many varieties. (See oolitic limestone, dolomitic limestone, crystalline limestone.) Limestones that contain not more than 5% magnesium carbonate may be termed calcite limestone, as distinguished from those that contain between 5 and 40% magnesium carbonate (magnesium or dolomitic limestone), and from those that contain in excess of 40% as the mineral dolomite (dolostone, formerly known as the rock dolomite). Recrystallized limestones and compact, dense, relatively pure microcrystalline varieties that are capable of taking a polish are included in commercial marbles.

LINERS: structurally sound sections of marble which are cemented to the back of marble veneer slabs to give greater strength, additional bearing surface, or to increase joint depth.

LINTEL: the block of stone spanning the top of an opening such as a doorway or window; sometimes called a head.

LIPPING: usually refers to flagging materials; caused when two pieces of material to be joined together are slightly warped or twisted causing one of more edges to be higher or lower than the adjoining material.

LUG SILL: a stone sill set into the jambs on each side of masonry opening.

M

MACHINE FINISH: the generally recognized standard machine finish produced by the planers.

MALPAIS: literally, badland; refers to dark colored rock, commonly lava, in rough terrain. As defined for architectural use: calcium carbonate with other components which give it color, markings, and texture suitable as a desirable building stone.

MARBLE (SCIENTIFIC DEFINITION): a metamorphic (recrystallized) limestone composed predominantly of crystalline grains of calcite or dolomite, or both, having interlocking or mosaic texture. Marble that contains less than S% magnesium carbonate may be termed calcite marble; from S-40% magnesium carbonate, magnesian or dolomitic marble; and more than 40%, dolomite marble. These limiting values are, however, not strictly established in petrologic science and are used herein as arbitrary limits.

-- ***ONYX:*** so called in trade, is a crystalline form, commonly microcrystalline, of calcium carbonate deposited usually from cold-water solutions. It is generally translucent and shows a characteristic layering. The term onyx marble is technically a misnomer, as true onyx is a variety of cryptocrystalline fibrous silica (chalcedony), and is closely related in form and origin to agate.

-- ***SERPENTINE:*** marble characterized by a prominent amount of the mineral serpentine.

-- ***TRAVERTINE:*** a form of limestone precipitated from ground waters, as in caves or in orifices of springs (see limestone).

-- ***VERDE ANTIQUE:*** a commercial marble composed chiefly of massive serpentine and capable of taking a high degree of polish. Verde antique is not a true marble in the scientific sense, but is commonly sold as a decorative commercial marble and requires the adjectival modifier verde (or verd) antique. Verde antique is commonly veined with carbonate minerals, chiefly calcite and dolomite.

MASONRY: built up construction, usually of a combination of materials set in mortar.

METAMORPHISM: the change or alteration in a rock caused by exterior agencies, such as deep-seated heat and pressure, or intrusion of rock materials.

MITER: the junction of two units at an angle of which the junction lines usually bisect on a 48 degree angle.

MODULAR MULTIPLE-CUT (PATTERN-CUT): this refers to standard patterns used throughout the stone industry. These patterns are usually based on multiples of a given height. Stone that is multiple cut or pattern cut is pre-cut to allow typically for ¼or 112 inch (6 or 13 mm) joints or beds.

MOLDINGS: decorative stone deviating from a plane surface by projections, curved profiles, recesses or any combination thereof.

MORTAR: a plastic mixture of cement, lime, sand and water used to bond masonry units.

MOSAIC: a veneering which is generally irregular with no definite pattern. Nearly all the stone used in a mosaic pattern is irregular in shape.

N

NATURAL BED: the setting of the stone on the same plane as it was formed in the ground. This generally applies to all stratified materials.

NATURAL CLEFT: this generally pertains to stones which are formed in layers in the ground. When such stones are cleaved or separated along a natural seam the remaining surface is referred to as a natural cleft surface.

NICKED BIT FINISH: obtained by planing the stone with a planer tool in which irregular nicks have been made in the cutting edge.

NON-STAINING MORTAR: mortar composed of materials which individually or collectively do not contain material that will stain, usually haven a very low alkali content.

0

OBSIDIAN: a glassy phase of lava.

ONYX MARBLE: a dense, crystalline form of lime carbonate deposited usually from cold-water solutions. Generally translucent and showing a characteristic layering due to mode of accumulation.

OOLITIC LIMESTONE: a calcite-cemented calcareous stone formed of shells and shell fragments, practically non-crystalline in character. It is found in massive deposits located almost entirely in Lawrence, Monroe, and Owen Counties, IN, and in Alabama, Kansas, and Texas. This limestone is characteristically a freestone, without cleavage planes, possessing a remarkable uniformity of composition, texture and structure. It possesses a high internal elasticity, adapting itself without damage to extreme temperature changes.

OPALIZED: the introduction into a rock of siliceous material in the form of opal, hydrous silicate.

OUT OF WIND: to be out of wind is to have the arris of the stone not in parallel or perpendicular lines. Stone which is out of wind has an irregular or rustic appearance.

P

PALLETIZED: a system of stacking stone on wooden pallets. Stone which comes palletized is easily moved and transported by modern handling equipment.

Palletized stone generally arrives at the job site in better condition than unpalletized material.

PANEL: a finished stone unit used on walls.

PARAPET WALL: that part of any wall entirely above the roof line.

PARGING: damp-proofing by placing a coat of 112 inch (13 mm) setting mortar to the back of stones or the face of the back-up material.

PARQUETRY: an inlay of stone floors in geometrical or other patterns.

PAVING: stone used as an exterior wearing surface, as in patios, walkways, driveways, etc. (see flooring).

PERFORATED WALL: one which contains a considerable number of relatively small openings, often called pierced wall or screen wall.

PERRONS: slabs of stone set on other stones serving as steps and arches in gardens.

PHENOCRYST: in igneous rocks, the relatively large and conspicuous crystals in a finer-grained matrix or ground mass.

PILASTER: an engaged pier of shallow depth. In classical architecture, it follows the height and width of related columns, with similar base and cap.

PITCHED STONE: stone having arris clearly defined; face, however, is roughly cut with pitching chisel used along the line which becomes the arris.

PLINTHS: the lower square part of the base of a column. A square base or a lower block, as of a pedestal. The base block to the juncture or baseboard and trim around an opening.

PLUCKED FINISH: obtained by rough-planing the surface of stone, breaking or plucking out small particles to give rough texture.

POINTING: the final filling and finishing of mortar joints that have been raked out.

POLISHED FINISH: the finest and smoothest finish available in stone characterized by a high luster (gloss) and strong reflection of incident light, generally only possible on hard, dense materials.

PORPHYRY: an igneous rock in which relatively large and conspicuous crystal (phenocrysts) are set in a matrix of finer crystals.

PRESSURE RELIEVING JOINT: an open horizontal joint below the supporting angle or hanger located at approximately every floor line and not over 15 feet (4.6 m) apart horizontally and every 20 to 30 feet (6 to 9 m) vertically to prevent the weight from being transmitted to the masonry below. These joints are to be caulked with a resilient non-staining material to prevent moisture penetration.

PROCESSING: the work involved in transforming building stone from quarry blocks to cut or finished stone. This includes primary sawing into slabs. It may also include both hand and mechanical techniques such as sawing, drilling, grinding, honing, polishing, and carving.

PROJECTIONS: this refers to the pulling out of stones in a wall to give an effect of ruggedness. The amount each stone is pulled out can vary between 1/2 and 1-1/2 inches (1.3 to 3.8 em). Stones are either pulled out at the same degree at both ends or sometimes one end is pulled out, leaving the other end flush with the majority of the veneer.

PUMICE: an exceptionally cellular, glassy lava resembling a solid froth.

Q

QUARRY: the location of an operation where a natural deposit of stone is removed from the ground.

QUARTZ: a silicon dioxide mineral that occurs in colorless and transparent or colored hexagonal crystal and also in crystalline masses. One of the most common minerals, the chief constituent of sandstone.

QUARTZITE: a compact granular rock composed of quartz crystals, usually so firmly cemented as to make the mass homogenous. The stone is generally quarried in stratified layers, the surfaces of which are unusually smooth. It's crushing and tensile strengths are extremely high; the color range is wide.

QUARTZITIC SANDSTONE: a sandstone with a high concentration of quartz grains and siliceous cement.

QUIRT: a groove separating a bed or other molding from the adjoining members.

QUOINS: stones at the corner of a wall emphasized by size, projection, rustification, or by a different finish.

R

RANGE: a course of any thickness that is continued across the entire face. All range courses need not be of the same thickness.

RECESS: a sinkage in a wall plane.

REGLET: a narrow, flat molding of rectangular profile.

RELIEF OR RELIEVE: ornament in relief. The ornament or figure can be slightly, half, or greatly projected.

RELIEVING .ARCH: one built over a lintel, flat arch or smaller arch to divert loads, thus relieving the lower member from excessive loading. Also known as discharging or safety arch.

RETURN: the right angle turn of a molding.

RETURN BEAD: stone facing with the finish appearing on both the face and the edge of the same stone, as on the corner of a building.

REVEAL: the depth of stone between its outer face and a window or door set in an opening.

RIBBON: narrow bands of rock differing to various degrees in chemical composition and color from the main body of the slate or stone; in other words, bands.

RIFT: the most pronounced (see "grain") direction of splitting or cleavage of stone.

Rift and grain may be obscure, as in some granites, but are important in both quarrying and processing stone.

RIP RAP: irregularly shaped stones used for facing bridge abutments and fills; stones thrown together without order to form a foundation or sustaining walls.

RISE: the heights of stones, generally used in reference to veneer stone.

ROCK: an integral part of the earth's crust composed of an aggregate of grains of one or more minerals. (Stone is the commercial term applied to quarry products.)

ROCK (PITCH) FACE: similar to split face, except that the face of the stone is pitched to a given line and plane producing a bold appearance rather than the comparatively straight face obtained in split face.

RODDING: reinforcement of a structurally unsound marble by cementing reinforcing rods into grooves or channels cut into the back of the slab.

ROMAN ARCH: semi-circular arch.

ROSE WINDOW: a circular stone window fitted with carved tracery.

ROUGH SAWN: a marble surface finish accomplished by the gangsawing process.

RUBBED FINISH: mechanically rubbed for smoother finish.

RUBBLE: a product term applied to dimension stone used for building purposes chiefly walls and foundations, and consisting of irregularly shaped pieces, partly trimmed or squared, generally with one split or finished face, and selected and specified with a size range.

RUSTICATION: chamfers or square sinkings round the face edges of individual stone to create shadows and to give an appearance of greater weight to the lower part of the building. When only the horizontal joints are sunk, the device is known as banded rustication.

S

SADDLE: a flat strip of stone projecting above the floor between the jambs of the door; a threshold.

SANDBLASTED: a matte-texture marble surface finish with no gloss, accomplished by exposing the surface to a steady flow of sand under pressure.

SAND-SEWN FINISH: the surface lift as the stone comes from the gangsaw; moderately smooth, granular surface varying with the texture and grade of the stone.

SANDSTONE: a sedimentary rock consisting usually of quartz, cemented with silica, iron oxide or calcium carbonate. Sandstone is durable, has a very high crushing and tensile strength and a wide range of color and textures. Varieties of sandstone are commonly designated by the kind and prominence of interstitial and bonding materials, as siliceous sandstone (bonding material primarily silica), calcareous sandstone (calcium carbonate prominent as bonding material or as accessory grains or both), argillaceous sandstone (clay minerals prominent as interstitial or bonding materials, or as thin laminae), ferringous sandstone (iron oxide or hydroxide minerals [hematic, limonite, et al] as interstitial or as bonding materials in sufficient amount to impart appreciable color to the stone); brownstone (ferringous sandstone of dark brown or reddish brown color), arkose, arkosic sandstone, or feldspathic sandstone (a sandstone that contains an abundance of grains offeldspar), conglomerate (a sandstone composed in large part of rounded pebbles, also called puddingstone).

The term "brownstone" was applied originally to certain Triassic sandstones of the Connecticut Valley in Massachusetts (Longmeadow sandstone), Connecticut (Portland sandstone), and to similarly appearing reddish-brown sandstone quarried in and near Hummelstown, PA. Thus the term originally had geographic significance, but such geographic limitation is undesirable.

SAWED EDGE: a clean cut edge generally achieved by cutting with a diamond blade, gangsaw or wire saw.

SAWED FACE: a finish obtained from the process used in producing building stone; varies in texture from smooth to rough and coincident with the type of materials used in sawing; characterized as diamond sawn, sand sawn, chat sawn and shot sawn.

SCALE: thin lamina or paper-like sheets of rock, often loose, and interrupting an otherwise smooth surface on the stone.

SCHIST: a loose term applying to foliated metamorphic (recrystallized) rock characterized by thin foliae that are composed predominantly of minerals of thin platy or prismatic habits and whose long dimensions are oriented in approximately parallel positions along the planes of foliation. Because of this foliated structure, schists split readily along these planes and so possess a pronounced rock cleavage.

The more common schists are composed of the micas and other mica-like minerals (such as chlorite) and generally contain subordinate quartz and/or feldspar of comparatively fine-grained texture; all graduations exist between schist and gneiss (coarsely foliated feldspathic rocks).

SCORIA: irregular masses of lava resembling clinker of slag; may be cellular (vesicular), dark-colored and heavy.

SCOTIA: a concave molding.

SCULPTURE: the work of a sculptor in three-dimensional form by cutting from a solid block of stone.

SEMI-RUBBED: a finish achieved by rubbing (by hand or machine) the rough or high spots off the surface to be used, leaving a certain amount of the natural surface along with the smoothed areas.

SERPENTINE: a hydrous magnesium silicate of igneous origin, generally a very dark green color with makings of white, light green or black. One of the hardest varieties of natural building stone.

SETTING SPACE: a term used to indicate the distance from the finished face of the marble to the face of the back-up wall.

SHAPED STONE: cut stone which has been carved, ground or other wise processed.

SHEAR: a type of stress; a body is in shear when it is subjected to a pair of equal forces which are opposite in direction and which act along parallel planes.

SHOT-SAWN: description of a finish obtained by using steel shot in the gangsawing process to produce random markings for a rough surface texture.

SHOT-SAWN FINISH: a rough gangsaw finish produced by sawing with chilled steel shots.

SILL: a flat stone used under windows, doors, and other masonry openings.

SILTSTONE: a fine-grained non-carbonate clastic rock composed of at least 67% of detrital grains of quartz and silicate minerals of silt size. Siltstones are rarely marketed as such but commonly are considered as fine-grained sandstones. This class of sediments is texturally transitional between sandstones and shales (mudstones). Many bluestones and siliceous flagstones fall within this category. The term is included in these definitions chiefly to explain the relationship of some silicious flagstones to the sandstone category.

SLAB: a lengthwise cut of a large quarry block of stone produced by sawing or splitting in the first milling or quarrying operation. A slab has two parallel surfaces.

SLATE: a very fine-grained metamorphic rock derived from sedimentary rock shale. Characterized by an excellent parallel cleavage entirely independent of original bedding, by which cleavage the rock may be split easily into relatively thin slabs. Essential mineral constituents of slates are usually members of the mica group, commonly sericite, muscovite, and paragonite; of the clay group, chiefly illite and kaolinite; and of the chlorite group. Common accessory minerals are iron oxides, calcite, quartz, and feldspar. Other minerals may be present also as minor accessories. Most slates are derived from shales. Others are derived from finegrained igneous rock, chiefly volcanic tuffs, but these are rare and of little commercial importance.

SLIP SILL: a stone sill set between jambs (see lug sill).

SMOOTH FINISH: description of the finish produced by planer machines plus the removal of objectional tool marks. Also known as "smooth planer finish" and "smooth machine finish."

SNAPPED EDGE, QUARRY CUT OR BROKEN EDGE: a natural breaking of a stone either by hand or machine. The break should be at right angles to the top and bottom surfaces.

SOAPSTONE: a massive variety of talc with a soapy or greasy feel used for hearths, washtubs, table tops, carved ornaments, chemical laboratory counters, etc., and known for its stain-proof qualities.

SOFFIT: the finished, exposed underside of a lintel, arch or portico.

SOUND STONE: stone which is free of cracks, fissures, or other physical defects.

SPALLS: sized may vary from chip-size to one-and two-man stones. Spalls are primarily used for taking up large voids in rough rubble or mosaic patterns.

SPANDREL WALL: that part of a curtain wall above the top of a window in one story and below the sill of the window in the story above.

SPLAY: a beveled or slanted surface.

SPLINE: a thin strip of material, such as wood or metal, inserted into the edges of two stone pieces or stone tiles to make a butt joint between them.

SPLIT: division of a rock by cleavage.

SPLIT FACE STONE: stone on which the face has been broken to an approximate plane.

SPLITSTONE FINISH: obtained by sawing to accurate heights then breaking by machine to required bed widths. (Normal bed widths are 3 112 inches [90 mm]).

SPOT OR SPOTTING: an adhesive contact, usually of plaster of paris, applied between the back of marble veneer and the face of the back-up wall to plumb or secure standing marble.

STACKED BOND: stone that is cut to one dimension and installed with unbroken vertical and horizontal joints running the entire length and height of the veneered area.

START: a small fissure.

STATUE: a sculpture or a human or animal figure.

STICKING: an expression used in the marble finishing trade to describe the process of cementing together of broken slabs or pieces of marble.

STONE: sometimes synonymous with rock, but more properly applied to individual blocks, masses or fragments taken from their original formation or considered for commercial use.

STOOL: a flat stone, generally polished, used as an interior sill.

STRATIFICATION: a structure produced by deposition of sediments in beds or layers (strata), laminae, lenses, wedges, and other essentially tabular units.

STRIP RUBBLE: generally speaking, strip rubble comes from a ledge quarry, the beds of the stone, while uniformly straight, are of the natural cleft as the stone is removed from the ledge, and then split by machine to approximately 4-inch (100 mm) widths.

STRIPS: long pieces of stone, usually low height ashlar courses, where length to height ratio is at maximum for the material used.

STYROLITE: a longitudinally streaked, columnar structure occurring in some marbles and of the same material as the marble in which it occurs.

SURROUND: an enframement.

T

TABLET: a small, flat slab or surface of stone, especially one bearing or intended to bear an inscription, carving or the like.

TEMPLATE: a pattern for repetitive marking or fabricating operation.

TERRAZZO: a type of concrete in which chips or pieces of a stone, usually marble, are mixed with cement and are ground to a flat surface, exposing the chips, which take a high polish.

THIN MARBLE: a fabricate marble unit of 2 inches (50 mm) or less in thickness.

THIN STONE/THIN VENEER: a cladding under 2 inches (50 mm) thick.

TILE: a thin modular stone unit.

TOLERANCE: dimensional allowance made for the inability of men and machines to fabricate a product of exact dimensions.

THROAT: the name sometimes given to the small groove under the windowsill or dripstone intended to deflect rain water from the wall face.

TOOLED FINISH: customarily has four, six, or eight parallel, concave grooves to the finish.

TRACERY: ornamentation of panels, circular windows, window heads, etc.

TRANSLUCENCE: the light-emitting quality of certain marble varieties containing a crystal structure capable of transmitting light.

TRAVERTINE LIMESTONE: a variety of limestone that has a partly crystalline or microcrystalline texture and porous or cellular layered structure, the cells being usually concentrated along certain layers and commonly displaying small stalactitic forms.

TRAVERTINE MARBLE: a variety of limestone regarded as a product of chemical precipitation from hot springs. Travertine is cellular with the cells usually concentrated in thin layers that display a stalactitic structure. Some that take a polish are sold as marble and may be classified as travertine marble under the class of commercial marble.

TREAD: a flat stone used as the top walking surface on steps.

TRIM: stone used as decorative items only, such as sill, coping, enframements, etc., with the facing of another material.

TRIMMER ARCH: a stone arch, usually a low-rise arch, used for supporting a fireplace hearth.

TUFF: cemented volcanic ash, many varieties included.

U

UNDERCUT: cut so as to present an overhanging part.

v

VEIN CUT: cutting quarried marble or stone perpendicular to the natural bedding plane.

VEININGS: colored markings in limestone, marble, alabaster, etc.

VENEER: a non-loadbearing facing of stone attached to a backing for the purpose of ornamentation, protection or insulation. Veneer shall support no vertical load other than its own weight and possibly the vertical dead load of veneer above.

VENEER STONE: a non-loadbearing facing of stone attached to a backing for the purpose of ornamentation, protection or insulation. Veneer shall support no vertical load other than its own weight and possible the vertical dead load of veneer above.

VENTING: a method used to allow air and moisture to escape to the outside from the wall cavity (see cavity vent).

VERDE ANTIQUE: a marble composed chiefly of massive serpentine and capable of being polished. It is commonly crossed by veinlets of other minerals, chiefly carbonates of calcium and magnesium.

W

WALL PLATE: a horizontal member anchored to a masonry wall to which other structural elements may be attached. Also called "head plate." Usually steel, 3/16-inch (5 mm) in diameter and formed in a "Z" shape or a rectangle.

WALL TIE: a bonder or metal piece which connects wythes of masonry to each other or to other materials.

WALL TIE CAVITY: a rigid corrosion-resistant metal tie which bonds two wythes of a cavity wall. It is filling of natural voids with color-blended materials.

WALLS: one of the sides of a room or building connecting floor and ceiling or foundation and roof:

- **-- *WALL BEARING:*** a wall supporting a vertical load in addition to its own weight.
- -- ***CAVITY:*** a wall in which the inner and outer wythes are separated by an air space but tied together with metal ties.
- -- ***WALL COMPOSITE:*** a wall in which the facing and backing are of different materials and bonded together with bond stones to exert a common reaction under load.
- -- ***WALL VENEER OR FACE:*** a wall in which a thin facing and the backing are of different materials but not so bonded as to exert a common reaction under load.
- -- ***WALL WIND (WINED):*** a twisting warp from cutting slabs in the gangsaws.
- -- ***WALL WYTHE:*** the inner or outer part of a cavity wall.

WARPED WALLS: generally a condition experienced only in flagging or flagstone materials; very common with flagstone materials that are taken from the ground and set in their natural state. To eliminate warping in stones, it would be necessary to further finish the material by methods such as machining, sand rubbing, honing or polishing.

WASH: a sloped area or the area water will run over.

WATER BAR: typically a strip in a reglet in windowsill and stone below to prevent water passage.

WATER TABLE: a projection of lowest masonry on the outside of the wall slightly above the ground. Often a damp course is placed at the level of the water table to prevent upward penetration of ground water.

WAXING: an expression used in the marble finishing trade to indicate the filling of natural voids with color-blended materials.

WEAR: the removal of material or impairment of surface finishing through friction or impact use.

WEATHERING: natural alteration by either chemical or mechanical processes due to the action of constituents of the atmosphere, surface waters, soil and other ground waters, or to temperature changes; the inclined top surface of a stone such as a coping, cornice, or windowsill.

WEDGING: splitting of stone by driving wedges into planes of weakness.

WIRE SAW: method of cutting stone by passing a twisted, multi-strand wire over the stone and immersing the wire in a slurry of abrasive material.