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Standard Guide for Petrographic Examination of Dimension Stone[1]

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1. Scope

1.1 This guide outlines procedures for the petrographic examination of stone specimen material proposed for use as dimension stone used in construction.

1.2 This guide outlines the extent to which petrographic techniques should be used, the selection of petrographic related properties that should be looked for, and the manner in which such techniques may be employed in the examination of dimension stone.

1.3 The rock and mineral names given in Terminology C119 should be used, insofar as they are appropriate, in reports prepared in accordance with this guide.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information purposes only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C97 Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone
C99 Test Method for Modulus of Rupture of Dimension Stone
C119 Terminology Relating to Dimension Stone
C120 Test Methods of Flexure Testing of Slate (Breaking Load, Modulus of Rupture, Modulus of Elasticity)
C121 Test Method for Water Absorption of Slate
C170 Test Method for Compressive Strength of Dimension Stone
C217 Test Method for Weather Resistance of Slate
C241 Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic
C406 Specification for Roofing Slate
C503 Specification for Marble Dimension Stone
C568 Specification for Limestone Dimension Stone
C615 Specification for Granite Dimension Stone
C616 Specification for Quartz-Based Dimension Stone
C629 Specification for Slate Dimension Stone
C880 Test Method for Flexural Strength of Dimension Stone
C1353 Test Method for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic Using a Rotary Platform Abraser
C1526 Specification for Serpentine Dimension Stone
C1527 Specification for Travertine Dimension Stone
C1528 Guide for Selection of Dimension Stone
C1799 Guide to Dimension Stone Test Specimen Sampling and Preparation
E883 Guide for Reflected–Light Photomicrography

3. Summary of Guide

3.1 The specific procedures employed in the petrographic examination of any specimen will depend to a large extent on the purpose of the examination and the nature of the specimen. In most cases the examination will require the use of optical microscopy. Complete petrographic examinations for particular purposes and to investigate particular problems may require examination of selected constituents by means of additional procedures, such as X-ray diffraction (XRD) analysis for crystalline structure, differential thermal analysis (DTA) for chemically and physically unstable minerals, infrared spectroscopy, scanning electron microscopy (SEM) energy dispersive X-ray analysis (EDX), or other procedures. Although these procedures are beyond the scope of this standard, these additional procedures may be more definitive than visual microscopic methods.

3.2 Identification of the minerals, composition, fabric, and structure of a specimen is a necessary step towards recognition of the properties that may be expected to influence the behavior of the material in its intended use, but identification is not an end in itself. The value of any petrographic examination will depend to a large extent on the representativeness of the specimens examined, the completeness and accuracy of the information provided to the petrographer concerning the source

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

and proposed use of the material, and the petrographer's ability to correlate these data with the findings of the examination.

3.3 This guide does not attempt to describe the techniques of petrographic work since it is assumed that the guide will be used by persons who are qualified by education and experience to employ such techniques for the recognition of the characteristic properties of rocks and minerals and to describe and classify the constituents of a specimen. For some cases, the petrographer will have had experience adequate to provide detailed interpretation of the petrographic results. For many cases the interpretation will be made, in part, by engineers, familiar with the intended use of the dimension stone. In other cases, interpretation of the findings may require input of others, such as a chemist, qualified to relate the observations to the questions to be answered.

3.4 The petrographer should be familiar with the ASTM standards referenced in 2.1.

4. Significance and Use

4.1 Petrographic examinations are made for the following purposes:

4.1.1 Determine the physical and chemical characteristics (mineralogy, texture, and composition) of the stone specimen that may be observed by petrographic methods and that have a bearing on the performance of the material in its intended use.

4.1.2 Describe and classify the minerals of the specimen.

4.1.3 Classify the stone both commercially and geologically based on Terminology C119, recognizing the differences in nomenclature; and based on the following standards, as appropriate:

Specification C406
Specification C503
Specification C568
Specification C615
Specification C616
Specification C629
Specification C1526
Specification C1527

4.1.4 Determine the relative amounts of the minerals of the specimen and constituents that have a bearing on the performance of the material in its intended use.

4.1.5 Compare characteristics of the stone with specimens from one or more sources, for which test data or performance records are available.

4.2 The petrographer should be told in as much detail as necessary, the purposes and objectives of the examination, the kind of information needed, and the extent of examination desired.

4.2.1 Pertinent background information, including results of prior testing, such as physical and mechanical testing, should be made available. The petrographer's advice and judgment should be sought regarding the extent of the examination. Available physical and mechanical testing may include the following:

Test Methods C97
Test Method C99
Test Method C170
Test Method C880
Test Methods C120
Test Method C121
Test Method C241
Test Method C1353
Test Method C217

4.3 This guide may form the basis for establishing arrangements between a purchaser of consulting petrographic service and the petrographer. In such a case, the purchaser and the consultant should together determine the kind, extent, and objectives of the examination and analyses to be made, and should record their agreement in writing. The agreement may stipulate specific determinations to be made, observations to be reported, funds to be obligated, or a combination of these or other conditions.

4.4 Petrographic examinations provide identification of type and varieties of minerals and structures present in the specimen. However, as noted above, identification of all minerals and structures present in the specimen is not required.

4.5 The petrographic examination should establish whether the specimen contains chemically unstable minerals or volumetrically unstable materials.

4.6 Petrographic examination should identify weathered or otherwise altered constituents or minerals and describe the extent of that weathering or alteration. Where possible, describe potential aesthetic changes that may occur as a result of weathering.

NOTE 1—If the dimension stone will be exposed to freezing and thawing and may become wet or saturated in use, finely porous and highly weathered or otherwise altered minerals should be identified because these materials will be especially susceptible to damage by freezing and thawing.

4.7 Petrographic examination should identify constituents or minerals and the extent to which they may lead to staining and color change of the surface of the stone when the stone is exposed to the weather for exterior use.

4.8 Petrographic examination should identify and estimate proportions of constituents that may be susceptible to deterioration from attack by deicing agents where proposed for use at grade level in freezing environments where deicing salts are anticipated to be used.

4.9 Criteria are available for identifying minerals by their optical properties or by XRD. Criteria are available for identifying rocks by their mineral composition and texture. Examination in both reflected and transmitted light may be necessary to provide data for these identifications. X-ray microanalysis using energy-dispersive X-ray spectrometers with scanning electron microscopy (SEM/EDX) or wavelength-dispersive X-ray spectrometers in electron microprobes (EMPA/WDX) may provide useful information on the chemical composition of minerals and rocks.

4.10 The objectives for which this guide was prepared, will have been attained if those involved with the evaluation of the specimen have reasonable assurance that the petrographic examination results, wherever and whenever obtained, may confidently be compared.

5. Sampling

5.1 Stone specimens for petrographic examination are best obtained under guidance of a geologist familiar with the requirements of this standard. Information on the exact location from which the specimen was taken and other pertinent data should be recorded or submitted with the specimen. The amount of material actually studied in the petrographic examination will be determined by the nature of the examination to be made and the nature of the material to be examined, as discussed below. It is preferable that the specimens be selected and prepared by the person performing the petrographic examination.

5.2 Specimen(s) provided for examination with unknown origin:

5.2.1 Often. specimens are submitted for petrographic analysis without information as to origin. In this case, report that the origin of the specimen is unknown or attempt to obtain information from the submitter as to country, quarry of origin, and geologic formation.

5.3 Specimen(s) selected from materials submitted for petrographic analysis as well as for physical and mechanical testing:

5.3.1 It is desirable to examine specimens that have been previously tested for physical and mechanical properties, for comparison with non-tested specimens. Petrographic analysis can sometimes explain anomalous physical and mechanical results as well as features that may be of concern, based solely on visual examination.

5.4 Specimen(s) selected from operating quarry for petrographic analysis.

5.4.1 Investigate vertical and lateral variations in the composition, texture, and microstructure of the material comprising the formation.

5.4.2 Examine specimen stone material produced that is representative of material to be used.

5.4.3 Identify visible features and characteristics and their variations to aid purchaser in selecting stone for use.

5.4.4 Provide description or sketch of quarry and proposed extraction location(s), and locations from which specimens for petrographic study were taken.

NOTE 2—Refer to Guide C1799 for additional information on selecting, preparing, and conditioning test specimens.

6. Procedure

6.1 Selection of Specimens for Direct Petrographic Examination:

6.2 Record:

6.2.1 Notes should be taken during the examination. Each specimen should be described; the relevant features may include the following: shape and dimensions of specimen,

6.2.2 Specimen surface textures and finishes,

6.2.3 Crystal or grain size, or both,

6.2.4 Internal structure, including observations of preferred orientation, segregation of grains or crystals, pore space, packing of grains, cementation of grains,

6.2.5 Color,

6.2.6 Rock name and minerals composition,

6.2.7 Significant heterogeneities in appearance,

6.2.8 General physical condition of the specimen (for example, freshness, weathering, alteration),

6.2.9 Presence of discontinuities (for example, rock cleavage, foliation, bedding, layering, fissures, fractures, vugs, stylolites, and fossils), and

6.2.10 Presence of constituents known to be chemically or physically unstable.

7. Report

7.1 State purpose of the examination.

7.2 Summarize the essential data needed to identify the specimen as to source and proposed use, and include a description giving the essential data on characteristics, composition, and properties of the material as revealed by the examination.

7.3 List the test procedures employed, and give a description of the nature and features of each important constituent of the specimen, accompanied by such tables and photographs as may be required.

7.4 Describe petrographic features, mineralogy, and structures observed that may have an effect on the physical, mechanical, and aesthetic performance of the material when used as dimension stone.

7.5 Express the findings and conclusions in terms likely to be intelligible to those who must make decisions as to the suitability of a material for use as dimension stone. Report observations made on features described in Section 6.

7.6 Describe qualitatively and, to the extent practicable, quantitatively, those properties or constituents that are known to have specific unfavorable effects. The unfavorable effects that may be expected to ensue should be mentioned.

NOTE 3—When appropriate, it should be stated that a given specimen was not found to contain any unfavorable features. When such is the case it may also be appropriate, especially if the report of the petrographic examination is not accompanied by reports of results of physical, mechanical, and chemical tests for which numerical limits may be applicable, to add that the material examined is considered to be acceptable for use provided the applicable acceptance tests are made and the results are within the appropriate limits. The report should not, however, contain conclusions other than those based upon the finding of the examination unless the additional data to support such conclusions are included in or with the petrographic report and the petrographer has been authorized to analyze the other relevant non-petrographic data.

7.7 Describe properties and characteristics including those which are likely to be significant relative to the intended use of the dimension stone including anticipated environmental exposure. These may include:

7.7.1 Descriptions of the shape and sizes of specimens examined in detail, and any other specimens examined,

7.7.2 Mineral structures sizes and size variation,

7.7.3 Classification of the stone both commercially and geologically based on Terminology C119, recognizing the differences in nomenclature,

7.7.4 Characteristics and orientation of bedding, foliation, or rift, including massiveness and susceptibility to cleaving, and whether these characteristics have the potential to affect strength or durability,

7.7.5 Veins, voids, vugs, stylolites, fossils, chips, and planes of weakness, such as cleavage planes, that may reduce strength or which may adversely affect strength at discreetly located connections used for support of the stone,

7.7.6 The presence of chips, cracks, dry seams, microcracks, seams, open seams, pits,

7.7.7 Where a finish has been provided: surface finish and texture, and whether the stone has been filled, such as with wax or resin, and

7.7.8 Observations on the variability within the specimen, and, if known, the variability of the formation from which the specimen was removed.

7.8 Provide interpretive descriptions, where possible, of structures, constituents and minerals that may:

7.8.1 Affect strength, or cause spalling or delaminations,

7.8.2 Result in run down staining, discoloration of stone, or changes in color of the stone over time, whether uniformly or at discrete locations,

7.8.3 Result in the development of organic growth on the stone when exposed to moisture for extended periods,

7.8.4 Result in susceptibility of the stone to dirt accumulation,

7.8.5 Result in chemical alteration of the finish, and

7.8.6 Result in change in color of the stone or of the finish.

7.9 Provide other interpretive descriptions, where possible:

7.9.1 Appropriateness and anticipated effects of rift, foliation, or bedding relative to proposed panel fabrication orientation, if known,

7.9.2 Effect of proposed stone size, shape, and thickness to be used relative to structures observed (for example, large mineral size relative to panel thickness, proposed orientation of bedding, and locations of stylolites),

7.9.3 Appropriateness and anticipated effects of the finish (or proposed finish if different) considering the minerals and structures observed,

7.9.4 Structures, constituents, and minerals that may explain inability of material to meet physical or mechanical test requirements, if appropriate,

7.9.5 Structures, constituents, and minerals that may have an effect on reducing the strength of connections, supports, and attachments if located at observed feature, if appropriate,

7.9.6 Water permeability if considered significant,

7.9.7 For slate, the potential for susceptibility to fading/weathering and the presence of ribbons,

7.9.8 The potential susceptibility to thermal hysteresis, and potential for dimensional instability such as bowing and warping. Historically this has mostly occurred in marble dimension stone, and

7.9.9 The susceptibility to wear where proposed for use as paving based on low hardness of composing minerals.

7.10 Provide known historic performance characteristics of the type of stone evaluated, if available, from other sources, including published literature and direct experience of petrographer.

7.11 Provide recommendations regarding any additional petrographic, chemical, physical, or geological investigations, or physical and mechanical testing to further evaluate potentially unfavorable or adverse properties that are indicated by the petrographic examination that has been performed.

NOTE 4—Supplementary petrographic investigations might include qualitative or quantitative analysis of the specific minerals of the specimen or of selected portions thereof by X-ray diffraction, differential thermal methods, or other procedures that are directed to identification and description of the constituents of the specimen. Also, if requested assistance in the selection of material for physical and mechanical testing that is judged to be representative of material to be used may be advisable.

8. Other Documents

8.1 Other documents, not specifically referenced in this standard, may be useful in performing petrographic examinations of Dimension Stone, including Guide C1528.

9. Precision and Bias

9.1 Those test methods that are used in connection with this guide that have been standardized in ASTM are subject to having precision and bias sections. Those that have not been standardized will each be provided with such a section, if and when standardized. None of the non-standardized procedures mentioned for optional use in this practice is used in ways that lend themselves to the preparation of precision and bias statements.

10. Keywords

10.1 composition; dimension stone; examination; microscopy; mineralogy; petrography; rock ; structure

APPENDIX

X1. APPARATUS AND SUPPLIES

X1.1 The apparatus and supplies listed as follows comprise a selection that will permit the use of the basic procedures described in this guide. All specific items and equipment listed have been used, in connection with the performance of petrographic examinations, by the procedures described herein; it is not, however, intended to imply that other items cannot be substituted to serve similar functions. Whenever possible the selection of particular apparatus and supplies should be left to the judgment of the petrographer who is to perform the work so that the items obtained will be those which the petrographer has the greatest experience and familiarity. The equipment regarded as typically considered essential to the making of petrographic examinations of specimens is listed.

X1.1.1 *Apparatus and Supplies for Preparation of Specimens:*

X1.1.1.1 *Rock-Cutting Saw* (preferably with 350-mm diameter or larger diamond blade, and automatic feed).

X1.1.1.2 *Horizontal Grinding Wheel* (preferably 400 mm in diameter).

X1.1.1.3 *Polishing Wheel* (preferably 200 to 300 mm in diameter).

X1.1.1.4 *Abrasives* (for example, silicon carbide grit No. 100 (122 µm), 220 (63 µm), 320 (31 µm), 600 (16 µm), and 800 (12 µm); alumina M-305 (5 µm)).

X1.1.1.5 *Geologist's Pick* or *Hammer*.

X1.1.1.6 *Microscope Slides*, clear, noncorrosive, 25 by 45 mm in size.

X1.1.1.7 *Mounting Media for Powder Mounts* (for example, Canada balsam, suitable low-viscosity epoxy resins; or Lakeside 70).

X1.1.1.8 *Mounting Media*, suitable for mounting rock slices for thin sections.

X1.1.1.9 *Laboratory Oven*.

X1.1.1.10 *Plate-Glass Squares*, approximately 300 mm on an edge for thin-section grinding.

X1.1.1.11 *Micro Cover Glasses* (for example, noncorrosive, square, 12 to 18 mm, 25 mm, etc.).

X1.1.1.12 *Plattner Mortar*.

X1.1.2 *Apparatus and Supplies for Examination of Specimens:*

X1.1.2.1 *Petrographic Microscope,* with mechanical stage; oculars and objective lenses that will allow magnifications of up to 600x, and objective-centering devices; full- and quarter-wave compensators; quartz wedge; micrometer eyepiece; Bertrand lens.

X1.1.2.2 *Microscope Lamps*.

X1.1.2.3 *Stereoscopic Microscope*, with objectives and oculars to give final magnifications from about 5 to about 100.

X1.1.2.4 *Magnet* (preferably Alnico, or an electromagnet).

X1.1.2.5 *Needleholder* and *Points*.

X1.1.2.6 *Dropper Bottle*, 60-mL capacity.

X1.1.2.7 *Steel Ruler* with 1 mm scale.

X1.1.2.8 *Forceps* (smooth, straight pointed).

X1.1.2.9 *Lens Paper*.

X1.1.2.10 *Refractive Index Liquids* (Immersion Media, n = 1.410 to n = 1.785 in steps of no more than 0.005).

X1.1.2.11 *Counter*.

X1.1.2.12 *Photomicrographic Camera* and accessories.

X1.1.3 The items under Apparatus and Supplies include those used to make thin sections. Semiautomatic thin-section machines are available, and there are several thin-section makers who advertise in mineralogical or geological journals. Laboratories may find it reasonable to buy a thin-section machine or use a commercial thin-section maker. Remotely located laboratories have more need to be able to make their own thin sections.

X1.1.4 Useful guidance regarding photomicrography, especially using reflected light, is found in Guide E883.