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CIBJO/Laboratories

CIBJO/GEMMOLOGICAL COMMISSION

The Gemmological Laboratory Book

A Guide for the Management and Technical Operations of Gemmological Laboratories

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Foreword

CIBJO is the French acronym for the **C**onfédération **I**nternationale de la **B**ijouterie, **J**oaillerie, **O**rfèvrerie, des Diamants, Perles et Pierres, which translates as the International Confederation of Jewellery, Silverware, Diamonds, Pearls and Stones (normally shortened to the International Jewellery Confederation). Founded in 1926 as BIBOAH, a European organisation whose mission was to represent and advance the interests of the jewellery trade in Europe, it was reorganised in 1961 and renamed CIBJO, in 2009 it was once again reorganised and officially named "CIBJO, The World Jewellery Confederation". Today CIBJO, which is domiciled in Switzerland, is a non-profit confederation of national and international trade associations including commercial organisations involved in the jewellery supply chain. It now has members from countries representing all five continents of the world. CIBJO printed its first deliberations on terminology and trade practices in 1968.

It is the task of CIBJO to record the accepted trade practices and nomenclature for the industry throughout the world. The records of the trade practices complement existing fair trade legislation of a nation or in the absence of relevant national laws they can be considered as trading standards. In countries where laws or norms exist, which conflict with the laws, norms or trade practices in other countries, CIBJO will support the national trade organisations to prevent trade barriers developing. The purpose of CIBJO is to encourage harmonisation, promote international co-operation within the jewellery industry, consider issues which are of concern to the trade worldwide and to communicate proactively with members. Foremost amongst these the aim is to protect consumer confidence in the industry. CIBJO pursues all of these objectives through informed deliberation and by reaching decisions in accordance with its Statutes. CIBJO relies upon the initiative of its members to support and implement its standards, and to protect the trust of the public in the industry.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The work of CIBJO is accomplished through Committees, Commissions and Sectors. Committees and Commissions consider standards for use in the jewellery supply chain. Sectors represent levels of trade in the jewellery industry. Sectors and commissions advise the Executive Committee on current trade practices and issues that affect the jewellery industry.

Three independent sectors exist within the confederation:

Sector A — The Products Sector

Sector B — The Supply Chain Sector

Sector C — The Service Sector

The Executive Committee may appoint Commissions that consider detailed issues. At present these are:

Coloured Stone

Coral

Diamond

Ethics

Gemmological

Pearl

Marketing & Education

Precious Metals

World Jewellers Vigilance

The Commissions for Diamonds, Gemstones, Pearls and Precious Metals have collated the guidelines, which present the accepted trade practices for applying descriptions to these materials. It is in the best interest of all those concerned to be aware of them.

The Sectors and Commissions will propose changes in the standards, also known as the Blue Books, to the Executive Committee. After review the Executive Committee will submit the accepted proposals for adoption to the Board of Directors and if approved they will notify the assembly of delegates of the changes at the annual congress. Furthermore, it is our mutual responsibility to support these recommendations, which concern all professional people connected with diamonds, gemstones, pearls and precious metals. CIBJO Standards are subject to government regulations in the respective jurisdictions of CIBJO members.

The national umbrella organisation for each country represents, in principle, all the national trade organisations involved in the sectors mentioned above. This democratic structure, which has contributed to CIBJO's world-wide recognition also includes international trade and commercial organisations, it provides an international forum for the trade to collectively draw attention to issues and implement resulting decisions.

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Introduction

The CIBJO Gemmological Laboratory Book is intended as a source of information and recommendations for gemmological laboratories on which they may choose to base their activities in order to ensure proper quality control and accountability within their Gemmological Laboratory.

The work of a Gemmological Laboratory and the test results it produces are reliant upon good practices throughout the Gemmological Laboratory's operation, from the first to the last interaction with the Customer.

The following definitions apply in understanding how to implement a CIBJO standard and normative references (Blue Books, PAS).

- “shall” indicates a requirement;
- “should” indicates a recommendation;
- “may” is used to indicate that something is permitted;
- “can” is used to indicate that something is possible.

The Gemmological Commission strongly recommends that all Gemmological Laboratories aspire to achieve the highest possible level of accountability throughout their operations and that the best practices recommended in the CIBJO Gemmological Laboratory Book are followed as a minimum. However, ideally all Gemmological Laboratories should also consider the application of ISO/IEC 17025.

The Gemmological Commission

October 2016

CIBJO Guidelines for Gemmological Laboratories

This book takes its concept from ISO/IEC 17025, an International Standard for which it is recommended that all Gemmological Laboratories seriously consider compliance.

Disclaimer — CIBJO recommends the best practices but is not responsible for gemmological reports issued by a Laboratory.

1. Scope

This CIBJO Gemmological Laboratory Book suggests best practices and general requirements for the competence to carry out tests, grading and/or internal calibrations, on instruments, coloured gemstones, diamonds and pearls within gemmological laboratories. The clauses herein are a guide only and shall not be regarded or considered as rules of application, laws, or statutes that govern the operation of gemmological laboratories.

The CIBJO Gemmological Laboratory Book suggests best practices for testing, grading and internal calibration performed using those methods both typically used and within gemmological laboratories as well as those uniquely developed. The suggestions are pertinent to the operations of all gemmological laboratories that issue test results regardless of whether or not these are part of a service that is paid for by a customer. They are also pertinent regardless of a gemmological laboratory's size and scope.

When a gemmological laboratory does not undertake one or more of the activities covered by this CIBJO Gemmological Laboratory Book, the suggestions stated in those clauses may not apply.

This CIBJO Gemmological Laboratory Book is for use by gemmological laboratories in developing their management system for quality, administrative and technical operations. It is not intended nor should it be considered as a guarantee for the quality of results issued by the laboratories.

Gemmological laboratories should refer to the appropriate International standards when organising compliance with safety requirements for the operation of gemmological laboratories: these are not covered in the CIBJO Gemmological Laboratory Book.

2. Normative references

The following referenced documents are recommended readings. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

International Standard, ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories ISO/IEC 17025:2005(E) Case postale 56 • CH-1211 Geneva 20, Web www.iso.org.

T**he Coral Book**, *CIBJO*, International Confederation of Jewellery, Silverware, Diamonds, Pearls and Stones, the World Jewellery Confederation, Viale Berengario,19, 20149 Milano, Italy. cibjo@cibjo.org

The Diamond Book, *CIBJO*, International Confederation of Jewellery, Silverware, Diamonds, Pearls and Stones), the World Jewellery Confederation, Viale Berengario, 19, 20149 Milano, Italy cibjo@cibjo.org.

The Gemstone Book, *CIBJO* (International Confederation of Jewellery, Silverware, Diamonds, Pearls and Stones), the World Jewellery Confederation, Viale Berengario, 19, 20149 Milano, Italy cibjo@cibjo.org.

The Pearl Book, *CIBJO* (International Confederation of Jewellery, Silverware, Diamonds, Pearls and Stones), the World Jewellery Confederation, Viale Berengario, 19, 20149 Milano, Italy cibjo@cibjo.org.

The Precious Metals Book, *CIBJO* (International Confederation of Jewellery, Silverware, Diamonds, Pearls and Stones), the World Jewellery Confederation, Viale Berengario, 19, 20149 Milano, Italy cibjo@cibjo.org.

PAS 1048, Grading polished diamonds, Part 1: Terminology and classification — Part 2: Test methods (2005), Beuth Verlag GmbH, Berlin. http://www.natdiamond.com/pas1048

3. Terms and definitions

3.1. Audit

examination of the quality, state, efficiency of an organisation, system, process, project or product to ascertain its validity and reliability.

3.2. Calibration

a set of graded measurements that show position or values to mark or correct the units of measurements of an instrument.

3.3. Certificate

a document of a legal standing.

3.4. Certified reference materials — CRMs

reference materials, accompanied by documentation issued by an authoritative body and providing one or more specified property values with associated uncertainties and traceability, using valid procedures.

3.5. Competent subcontractor

a contractor of the primary contractor, in this case the laboratory, who by virtue of their knowledge, experience and equipment is competent to do the work.

3.6. Gem materials

those materials listed in the CIBJO, Diamond, Pearl, and Gemstones Books (see 2, Normative References).

3.7. Gemmological laboratory

an establishment that provides controlled conditions in which the identification, authentication and grading of gem materials may be performed; scientific research, experiments and measurements may be carried on as well with the aim of a better knowledge of gem materials.

3.8. Gemmology

the science, art and profession of identifying, authenticating, researching and grading gem materials.

3.9. Gemological laboratory

an alternative (American English) spelling for gemmological laboratory.

3.10. Gemology

an alternative (American English) spelling for gemmology

3.11. Grading

the classification of technical/commercial characteristics of gem materials

3.12. Internal audit

control of the Laboratory's quality system, to ensure that the activities carried out in the Laboratory are in conformity with the established policies and procedures of the management system, with the aim of correcting any non-conformities and introducing improvements. The final outcome is to minimize the percentage of errors and give valid, consistent and reliable results and services.

3.13. Internal calibrations

calibrations done in a Centre on its own instruments, to check their validity and consistency with the Standards.

3.14. Laboratory / Lab

trade short form for a gemmological laboratory, see 3.7 and 3.9.

3.15. Quality and technical record

written notes on facts related to quality and/or to technical items so that they can be remembered or referred to in the future.

3.16. Reference standards and reference materials

references calibrated by a body that can provide traceability, used to establish, by comparison, the value of physical or chemical properties.

3.17. Report

a description of technical/commercial characteristics of gem materials in accordance with the rules relative to CIBJO international agreements.

3.18. Sampling

a defined procedure whereby a part of a substance, a material, a product or a lot is taken to provide for testing of a representative sample of a whole. Sampling procedures describe the selection, sampling plan, withdrawal and preparation of a sample or samples from a substance, material, product or a lot, to yield the required information.

3.19. SI units – International System of Units

an internationally agreed system of measurement that uses seven base units (length, mass, time, electric current, thermodynamic temperature, luminous intensity and amount of substance) with two supplementary units (plane angle and solid angle).

3.20. Subcontract

a contract that assigns some of the obligations of a prior contract to another party.

3.21. Test

a procedure in which technical characteristics of gem materials are observed, measured, analysed and established**.**

3.22. Traceability

completeness of the information about every step in a process chain.

3.23. Reproducibility of results

ability of a gemmological laboratory to get the same results when repeating tests, using the same reference samples and standards.

4. Management requirements

4.1. Organisation

4.1.1. The gemmological laboratory, the organisation, or commercial company of which it is part shall be legally responsible for the activities of the gemmological laboratory. The management system shall cover work carried out by the gemmological laboratory whether inside or outside the political/administrative borders of its registration.

4.1.2. In order to make clear any implied or potential conflicts of interest, if a gemmological laboratory is entirely or partly owned by, or has investors within a gem material (loose or mounted) trade organisation or a commercial company that trades in gem materials (loose or mounted), in particular where traders or potential customers are on a board(s) and may play a role in, or have an influence upon the testing and/or reporting activities of the

gemmological laboratory; the responsibilities of key personnel in the organisation that have such involvement or influence shall be clearly defined, and openly declared to the Laboratory's clients.

4.1.3. A gemmological laboratory should be able to demonstrate that it is impartial and that it and its personnel are free from any undue commercial, financial and other pressures which might influence their technical judgement. The gemmological laboratory should not engage in any activities that may endanger the trust in its independence of judgement and integrity in relation to its testing or internal calibration activities.

4.1.4. The gemmological laboratory management system shall ensure that gemmological laboratory personnel are free from any internal and external pressures and influences that may interfere with the quality of their work; the performance of tests, grading and/or instrument calibrations. The management system shall have personnel in-place that monitor such influences and when necessary have the power to take corrective action.

4.1.5. The management system shall be clearly defined to staff and customers through an effective means of communication.

4.1.6. Testing and internal calibrations shall be properly supervised by technically qualified managers that have overall responsibility and authority over technical staff and the work they carry out, and reports that are issued.

4.1.7. A member of the technical staff shall be appointed to manage the quality of the work carried out in the gemmological laboratory. This manager shall ensure that all test protocols are adhered to, that quality systems are followed at all times that the staff is aware of their quality related responsibilities at all times.

4.2. Management systems

4.2.1. A system of protocols that ensure the quality of the work carried out by the gemmological laboratory shall be available to the staff and that the contents are effectively communicated. These protocols shall cover all aspects of the gemmological laboratory functions, including but not limited to, receipting of goods, weights and measures, inventory control, work distribution, instrument maintenance and operation, results analysis and report nomenclature.

4.2.2. All management systems shall be reviewed at least annually and a written quality statement issued by top management. This statement shall commit management to the observation of best practices in the identification and reporting on gem materials and the quality of services given to customers. The statements should also indicate management's commitment to compliance with the Gemmological Laboratory Book and / or ISO/IEC 17025.

4.3. Document Control

4.3.1. A full list of approved documents and their current status shall be established and shall be readily available to preclude the use of out of date versions. All approved documents shall be available in and to all locations.

4.3.2. All altered or new document text shall be identified in the document or the appropriate attachments.

4.3.3. There shall be clear procedures to describe how changes in documents are made and controlled.

4.3.4. Documents must include the list of related attachments.

4.4. Review of customer requests

4.4.1. Requirements and or requests shall be clearly established upon receiving gem materials from a customer.

4.4.2. All test methods shall be adequately defined and be clearly understood by the gemmological laboratory.

4.4.3. The gemmological laboratory shall have the capability and resources to meet the customer's requirements and/or requests.

4.4.4. Any differences in understanding between the customer and the gemmological laboratory shall be resolved prior to any work being carried out.

4.4.5. Records shall be kept of any discussions with customers.

4.5. Subcontracting of tests

4.5.1. When a gemmological laboratory subcontracts work, this work shall be placed with a competent subcontractor.

4.5.2. If customer's work is subcontracted the gemmological laboratory shall advise customers of the circumstances, including the acknowledgement of their continued responsibility for the gem materials submitted.

4.6. Service to the customer

4.6.1. Within the limitations set by security requirements, the gemmological laboratory shall agree to any customer request for the monitoring of performance related to the work performed, provided also that the gemmological laboratory ensures confidentiality to other customers.

4.6.2. The gemmological laboratory shall seek feedback from its customers. This feedback shall be used to improve the management system, testing and internal calibration activities and customer services.

4.7. Complaints

4.7.1. The gemmological laboratory shall have a policy and procedure for the resolution of complaints received from customers or other parties. Records shall be maintained of all complaints and of the investigations and corrective actions taken by the gemmological laboratory.

4.7.2. A secondary customer should make any complaints through the primary customer. Responses to complaints shall be given to the primary customer only.

4.8. Corrective action

4.8.1. The gemmological laboratory shall establish a policy and a procedure and shall designate appropriate authorities for implementing corrective action when departures from the policies and procedures in the management system or technical operations have been identified.

4.9. Additional audits

4.9.1. Where the identification of departures casts doubts on the gemmological laboratory's compliance with its own policies and procedures, or on its compliance with this CIBJO Gemmological Laboratory Book, the gemmological laboratory shall ensure that the appropriate areas of activity are audited as soon as possible.

4.10. Control of records

4.10.1. The gemmological laboratory shall establish and maintain procedures for identification, collection, indexing, access, filing, storage, maintenance and disposal of quality and technical records. Quality records shall include reports from internal audits and management reviews as well as records of corrective and preventive actions.

4.11. Internal audits

4.11.1. The gemmological laboratory shall periodically conduct internal audits of its activities to verify that its operations continue to comply with the requirements of the management system and this CIBJO Gemmological Laboratory Book. Such audits shall be carried out by trained and qualified personnel who are, wherever resources permit, independent of the activity to be audited.

4.12. Management reviews

4.12.1. The gemmological laboratory's top management shall periodically conduct a review of the gemmological laboratory's management system and testing and/or internal calibration activities to ensure their continuing suitability and effectiveness, and to introduce necessary changes or improvements. The review shall take account of

- the suitability of policies and procedures;
- reports from managerial and supervisory personnel;
- the outcome of recent internal audits;
- corrective and preventive actions;

- assessments by external bodies;
- the results of inter laboratory comparisons or proficiency tests;
- changes in the volume and type of the work;
- customer feedback;
- complaints;
- recommendations for improvement;
- other relevant factors, such as quality control activities, resources and staff training.

A typical period for conducting a management review is once every 12 months. Results should be fed into the laboratory planning system and should include the goals, objectives and action plans for the coming year.
A management review includes consideration of related subjects at regular management meetings.

5. Technical requirements

Many factors determine the correctness and reliability of the tests, grading and/or internal calibrations performed by a gemmological laboratory. These factors include contributions from:

- human factors;
- accommodation and environmental conditions;
- test and calibration methods and method validation;
- equipment;
- measurement traceability;
- samples;
  the handling of test and calibration items.

5.1. Personnel

5.1.1. The gemmological laboratory management shall ensure the competence of all who operate specific equipment, perform tests and/or internal calibrations, evaluate results, and sign test reports. When using staff that are undergoing training, appropriate supervision shall be provided. Personnel performing specific tasks shall be qualified on the basis of appropriate education, training, experience and/or demonstrated skills, as required. The gemmological laboratory shall maintain current anonymous job descriptions for managerial, technical and key support personnel involved in tests and/or internal calibrations.

5.1.2. The gemmological laboratory should count on the presence of a minimum of three persons as defined in 5.1.1.

5.2. Accommodation and environmental conditions

5.2.1. Gemmological laboratory facilities for testing and/or grading and internal calibration shall be such as to facilitate correct performance of the tests and/or grading and in line with international agreements. The gemmological laboratory shall ensure that the environmental conditions do not invalidate the

results or adversely affect the required quality of any measurement. The technical requirements for accommodation and environmental conditions that can affect the results of tests and grading shall be documented.

5.3. Equipment

5.3.1. The gemmological laboratory shall be furnished with all items of equipment required for the correct performance of the tests and/or grading and internal calibration. See also CIBJO Application Document for Laboratories (www.cibjo.org). In those cases where the gemmological laboratory needs to use equipment outside its permanent control, it shall ensure that the requirements of this CIBJO Gemmological Laboratory Book are met.

5.3.2. Equipment shall be operated by authorised personnel. Up-to-date instructions on the use and maintenance of equipment shall be readily available for use by the appropriate gemmological laboratory personnel.

5.3.3. Records shall be maintained of each item of equipment and its software significant to the tests, grading and/or internal calibrations performed. The records shall include at least the following:

- date of purchase
- the identity of the item of equipment and its software;
- the manufacturer's and distributors name, type identification, and serial number or other unique identification;
- checks that equipment complies with the specification;
- the current location, where appropriate;
- the manufacturer's instructions, if available, or reference to their location;
- dates, results and copies of reports of all calibrations, adjustments, acceptance criteria and the due date of next calibration;
- the maintenance plan, where appropriate, and maintenance carried out to date;
- any damage, malfunction, modification or repair to the equipment.

5.4. Testing and grading

5.4.1. Where traceability of measurements to SI units is not possible and/or not relevant, the same requirements for traceability to, for example, certified reference materials, agreed methods (see under 6.) and/or consensus standards, are required.

5.5. Reference standards and reference materials

5.5.1. The gemmological laboratory shall have a programme and procedure for the calibration of its reference standards. Reference standards shall be calibrated by a body that can provide traceability. Such reference standards held by the gemmological laboratory shall be used for calibration only and for no other purpose, unless it can be shown that their performance as reference standards would not be invalidated.

5.6. Sampling

5.6.1. The gemmological laboratory shall have a sampling plan and procedures for sampling when batch testing. The sampling plan as well as the sampling procedure shall be available at the location where sampling is undertaken. Sampling plans shall, whenever reasonable, be based on appropriate statistical methods.

5.6.2. Where the customer requires deviations, additions or exclusions from the documented sampling procedure, these shall be recorded in detail with the appropriate sampling data and shall be included in all documents containing test and/or calibration results, and shall be communicated to the appropriate personnel.

5.7. Assuring the quality of test and grading results

5.7.1. The gemmological laboratory shall have quality control procedures for monitoring the validity and results reproducibility of tests, grading and internal calibrations undertaken. The resulting data shall be recorded in such a way that trends are detectable and, where practicable, statistical techniques shall be applied to the reviewing of the results.

5.8. Reporting the results

5.8.1. Each test report shall include at least the following information, unless the gemmological laboratory has valid reasons for not doing so:

- a title (e.g. “Test Report”);
- the name and address of the gemmological laboratory, and the location where the tests were carried out, if different from the address of the gemmological laboratory;
- unique identification of the test report (such as the serial number), and on each page an identification in order to ensure that the page is recognised as a part of the test report, and a clear identification of the end of the test report;
- the name and address of the customer (client optional);
- a description of, the condition of, and unambiguous identification of the item(s) tested;
- the date of receipt of the test item(s) where this is critical to the validity and application of the results, and the date(s) of performance of the test;
- the test or grading results with, where appropriate, the units of measurement;
- opinions and interpretations where appropriate and needed; in many cases it may be appropriate to communicate the opinions and interpretations by direct dialogue with the customer : such dialogue should be written down.
- additional information which may be required by specific methods, customers or groups of customers;
- the name(s), function(s) and signature(s) or equivalent identification of person(s) authorising the test report or the name of the legal entity.

5.8.2. In the case of transmission of test results by telephone, telex, facsimile or other electronic or electromagnetic means, the guidelines of this CIBJO Gemmological Laboratory Book shall be met.

5.8.3. The format of the report shall be designed to accommodate each result obtained and to minimise the possibility of misunderstanding or misuse. The headings should be standardized as far as possible.

5.8.4. The report should have suitable security measures, such as a hologram or embossed seal, to minimise potential for fraud.

5.8.5. Copies of reports, working notes, etc. shall be retained in a secure manner for at least 10 years, or longer if local regulations require.

5.9. Amendments to test reports

5.9.1. Material amendments to a test report after issue shall be made only in the form of a further document, or data transfer, which includes the statement: "Supplement to Test Report, serial number … or an equivalent form of wording. When it is necessary to issue a complete new report, this shall be uniquely identified and shall contain a reference to the original that it replaces.

6. Test method protocol

Required test methods are listed, which shall be applied to correctly identify the gem material stated. The listed test method is mandatory, unless a remark indicates otherwise. Definitions of the test methods are listed under 6.3. and the indicated key references on which the protocol is based, are given under 6.4.

6.1. Test methods gemstones

6.1.1. Actinolite

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive

References

Burns and Greaves (1971); Crowningshield (1969); Fryer (1993a); Hietanen (1971); Ishida et al. (2002); Lucas (1974); Mustard (1992); Pough (1987); Skogby and Annersten (1985); Smelik et al. (1991); Washington and Merwin (1923)

Special attention: dye

6.1.2. Alexandrite

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye, colour-change
Refractometer (refractive index)	
Spectroscope	
FTIR(-NIR) spectroscopy	
Colour call	Clear colour-change
Clarity enhancement check/extent	

References

Anderson (1950); Andres et al. (1962); Bank F.H. et al. (1988); Bank (1964, 1967, 1971, 1974, 1987); Bank H. et al. (1988a,b), Bank and Okrusch (1967); Beaume et al. (1997); Benson (1959a, b), Bevan and Downes (1997), Brown and Kelly (1985), Bukin et al. (1981), Cassedane and Roditi (1993), Crowningshield (1963a, 1964, 1970b, 1979); Currie (1994), de Oliviera and Leite (1987), Du Toit (1996), Eppler (1974), Fryer, (1983a, b, 1986, 1987, 1988a, b, 1992, 1993b); Galia (1990); Godovikov and Bulgak (1989); Gravender (1935); Grum-Grzhimailo (1949); Gübelin and Schmetzer (1980); Gübelin (1976a,b,c,d); Guo et al. (1987); Hassan and El-Rakhawy (1974); Henn (1985); Henn and Bank (1992); Horiuchi (1979); Hyrsl and Quintens (1999), Johnson and Kammerling (1995), Kammerling and Fryer (1995a,b,c); Kane (1987); Koivula (1984, 1987); Koivula and Fritsch (1993b,c); Koivula et al. (1988a); Koivula and Kammerling (1988b, 1991c, 1992a); Koivula et al. (1992b); Koivula et al., 1995; Leckebusch (1976); Leithner (1980); Liddicoat (1972b, 1974b, 1976a); Liu and Fry (2006); Machida and Yoshihara (1980); Malley (1988); Panjikar and Ramchandran (1997); Payne (1956); Powers (1993); Proctor (1988); Scarratt (1988, 1992a,b); Schmetzer et al. (1996, 1997a); Stockton and Kane (1988); Trossarelli (1986); Webster (1938)

Special attention: clarity enhancement, synthetics, clear colour-change

6.1.3. Amblygonite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	
XRD	If other tests are inconclusive

References

Angino (1964); Berman and Gonyer (1930); Cerna et al., (1973), Chikayama (1981), Crowningshield (1959, 1960, 1962), Fransolet and Tarte (1977), Greiner and Bloss (1987), Groat et al.(1990), Gubelin (1955), Heinrich and Corey (1955), Koivula (1986), Liddicoat (1963), Loh and Wise (1976), London (1984), London et al. (2001), Moss et al. (1969), Murdoch (1955), Nel (1946), Palache et al. (1943), Weibel (1956), Winchell (1926)

6.1.4. Ammonite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive

References

Chikayama (1981), Koivula and Kammerling (1991), Wight (1981), Zakrevskaya (1995)

Special attention: coating, impregnation

6.1.5. Anatase

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
EDXRF chemistry	
Raman spectroscopy	
XRD	If other tests are inconclusive
References	
Banfield, et al. (1991), Chesnokov (1960), Garmo (1989), Liu and Mernagh (1992), Millette, et al. (1993), Parker (1923), Pough (1987), Schuiling and Vink (1967), Wehr, et al. (2008).	

6.1.6. Andalusite

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Dichroscope (pleochroism)	
Spectroscope	
XRD	If other tests are inconclusive
References	
Abs-Wurmbach, et al. (1977), Ahn, et al. (1988), Anderson (1967), Aryal, et al. (2008), Austen (1941, Bank (1972), (1981a, b, c,) Baron (1981), Bastos (1984), Berger (1997), Bohlen, et al. (1991), Bridges (1982), Brightman (1982, Carlson and Rossman (1988), Cassedanne, J. (1985), Cassedanne, J.P. and Cassedanne (1980), Crowningshield (1959a, b, c,) (1960a, b, c,) (1961a, b,) (1970a, b,) Deen (1984), Dharmaratne (1998), Dowty (1976), Dunn (1976), Faye and Harris (1969, Finger and Prince (1972), Fryer (1986), (1990), Garsche, et al. (1991), Grapes (1987), Gunter and Bloss (1982), Harlov and Newton (1993), Heinrich and Corey (1959), Hemingway, et al. (1991,) Heung, et al. (1994), Hietanen (1956), Holdaway and Mukhopadhyay (1993), Iishi, et al. (1979), Johnson and Koivula (1998), Kai, et al. (1980), Koivula (1980), (1984), Koivula and Kammerling (1991b), Langer (1979), Macdonald and Merriam (1938), Mitchell (1986), Murdoch (1936), Pearson and Shaw (1960), Peck (1924), Pinet, et al. (1992), Pough (1964), (1988), Ramsey (1988), Richmond (1940), Roger (1987), Rose (1957), Roy (1954), Ruplinger (1983), Schnellrath (1990), Smith (1977), Smith, et al. (1982), Theye and Fransolet (1994), Webb (1943), Weill (1963), Wilkins and Sabine (1973), Winkler and Buehrer (1990), Winkler, et al. (1991), Zoysa (1991), Zwaan (1955)	

6.1.7. Apatite

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye, colour-change
Refractometer (refractive index)	
Hydrostatic weighing	

(specific gravity)	
Spectroscope	
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive

References

Anderson (1972), Audeon (1991), Bank (1975, 1976a, 1988), Bank et al. (1988, 1989, 1990), Barbarand and Pagel (2001); Barot et al., 1995; Baumer and Argiolas (1981); Boyd and Wight (1981); Bridges (1982); Brown et al. (1989); Burragato et al. (1982); Cario (1989); Cooray (1970); Crowningshield (1959, 1960a,b, 1961, 1963a,b,c, 1965a,b, 1966a,b, 1972, 1973); Deen (1984); Dharmaratne (2002), Dunn (1977); Field (1948), Fryer (1982), Gubelin and Schmetzer (1982), Gubelin (1967a), Hyrsl and Petrov (1998), Johnson and Koivula (1999), Koivula (1980), Koivula and Fritsch (1993, 1994a, 1995a, 1995b), Koivula and Kammerling (1990a,b, 1991, 1992a,b), Landes (1938), Leventouri et al. (2001), Liddicoat (1962a,b, 1963a,b, 1965a,b, 1971), O'Donoghue (1976), Payne (1995), Poirot (1983), Randriamanga (1994), Remaut and Vochten (1985, 1986), Rosasco and Roedder (1979), Rutland (1954), Szenics (1967), Teng et al. (2006), Trzcienski et al. (1974), Whitlock (1925), Zharinov et al. (2008), Zwaan (1965, 1981, 2015a)

6.1.8. Aquamarine

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	If RI not possible (rough)
Dichroscope	
Spectroscope	
EDXRF chemistry	If synthetic or irradiation is suspected
Colour call	
Clarity enhancement check/extent	

References

Algier (2007), Bank et al. (2001), Bank and Henn (1990), Bank et al. (1989), Barot et al. (1995), Bastos (1964), Brown (1985), Crowningshield (1972, 1980), de Goutiere (1993), Duroc-Danner (1989), Eppler (1962), Farn (1973), Fryer (1981, 1984, 1985), Groat et al. (2008), Hänni (1992), Henn (1999a,b), Henn and Bank 91992), Jacobson (1993), Johnson and Koivula (1998), Kammerling et al. (1991), Koivula (1985a), Koivula and Kammerling (1989a,b,d, 1990), Koivula et al. (1992b), Letson (1980), Li (2001), Liccini (1998), Lind et al. (1986), Lindner and Rolff (1967), Middlemiss and Parshad (1918), Milisenda and Bank (2005), Monistier (2006), Moses et al. (1997), Nassau (1977, 1987), Natkaniec-Nowak (2008), Panjikar (1994), Petsch (1990), Phukan (1966), Scarratt (1989a,b), Schmetzer (1989), Segura and Fritsch (2003), Zeitner (1988), Zwaan and Zoysa (2008)

Special attention: heat treatment, irradiation (Maxixe), clarity enhancement, coatings, synthetics

6.1.9. Aragonite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	

XRD	If other tests are inconclusive

References

Alder and Kerr (1962), Anderson (1978), Barik et al. (2004), Belcher et al. (1996), Bischoff (1969), Brink and van der Berg (2005), Chateigner et al. (2000), Chave and Schmalz (1966), Checa et al. (2006), Clark and Lutz (1980), Compere and Bates (1973), Cuif (1992), Cuif et al. (1993), Dal Negro and Ungaretti (1971), de Villiers (1971), Falini et al. (1996), Faust (1950), Gauthier et al. (1994, 1997), Giles et al. (1995), Greegor et al. (1996), Hattan et al. (2001), Hyrsl (1996), Koivula and Fritsch (1993), Koivula et al. (1992), Komatsu et al. (1993), Konishi and Saki (1972), Korago et al. (1978), Low and Ziera (1972), Ma et al. (2007), MacDonald (1956), Makovicky and Karup-Moller (2006), McTigue and Wenk (1985), Narasimhulu and Rao (2000), Pinet et al. (1992), Pough (1988), Ronneberg et al. (1979b), Sen et al. (1994), Soldati et al. (2008), Steinen (1982), Urmos et al. (1991), Watabe (1955), Webster (1973), Zhang C. et al. (2006), Zhang W.A. et al. (2007), Zhou et al. (2009)

Special attention: dye

6.1.10. Axinite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Dichroscope (pleochroism)	
Spectroscope	
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive

References

Andreozzi et al. (2000a,b), Cassedanne and Cassedanne (1977), Cassedanne et al. (1983), Crowley (1983), Crowningshield (1960, 1963), Cummings (1983), Deen (1984), French and Fahey (1972), Frost et al. (2006), Hänni (1982), Jobbins et al. (1975), Kalachev (1993), Koivula and Kammerling (1992), Lumpkin and Ribbe (1979), Peacock (1937, 1938), Pinet et al. (1992), Pohl et al. (1982), Pough (1988), Sanero and Gottardi (1968), Schmetzer (1978), Sinkankas (1965, 1998)

6.1.11. Benitoite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	Higher index may exceed limit refractometer
Hydrostatic weighing (specific gravity)	
Dichroscope (pleochroism)	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
Raman spectroscopy	If other tests are inconclusive

References

Benson (1960), Brown (1997), Crowningshield (1960a,b), Frazier and Frazier (1990a), Gaft et al. (2004, 2005), Gray (1992, 1994), Hawthorne (1987), Hlawatsch (1909), Laird and Albee (1972), Launer (1952), Laurs et al. (1997), Liddicoat (1963, 1967a, 1968), Louderback (1907), Mitchell (1980), Pinet et al. (1992), Rase and Roy (1955), Zachariasen (1930).

6.1.12. Beryl (yellow, colourless, pink, red)

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Dichroscope (pleochroism)	
Clarity enhancement check/extent	

References

Anonymous (1999, 2000c), Austin 92002), Baker et al. (2002), Barres et al. (2003), Bekker and Barz (2007), Christenson and Austin (1999), Demianets et al. (2006), Dharmaratne (1999, 2002), Federman (2000a), Fumagalli et al. (2003), Hänni and Krzemnicki (2003a,b, 2004), Henn and Milisenda (1999a,b), Jones (2005), Kleismantas (2003), Kopchikov and Shelementiev (2004), Li (2001), Mathew et al. (1998), Monistier (2006), Moroz et al. (1999b), Moses et al. (1998a,d), Natkaniec-Nowak (2008), Pezzotta (2005a), Qi (2002), Schmetzer et al. (2008), Thompson et al. (2002), White (2005)

Special attention: clarity enhancement, synthetics

6.1.13. Beryllonite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive

References

Bank et al. (1994), Cerna et al. (2002), Crowningshield (1960), Dunn (1975), Henn and Bank (1994), Koivula and Kammerling (1991), Liddicoat (1962), Pinet et al. (1992)

6.1.14. Brazilianite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	

References

Bookstone (1964), Cassedanne (1981, 1983), Chikayama (1981), Crowningshield (1960, 1962a,b), Dillon (1982), Frondel and Lindberg (1948), Hurlbut and Weichel (1946), Hyrsl (1997), Liddicoat (1971), Pinet et al. (1992), Pough and Henderson (1945), Reeve (1972), Swoboda (1947)

6.1.15. Calcite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing	

(specific gravity)	
FTIR(-NIR)	If other tests are inconclusive
Raman spectroscopy	If other tests are inconclusive

References

Alder and Kerr (1962), Alfonso et al. (1999), Bischoff et al. (1983), Borodin and Nefedova (2005), Chave and Schmalz (1966), Compere and Bates (1973), Crowningshield (1959, 1975), Cuif (1992), Cuif et al. (1993), Falini et al. (1996), Faust (1950), Fryer (1981, 1986, 1987, 1989a, 1990b), Gauthier et al. (1994, 1997), Gillet and Madon (1982), Guse (1982), Hassan (1978), Huang and Kerr (1960), Hurlbut and Francis (1984), Jacob et al. (2008), Kammerling et al. (1991, 1995), Koivula and Johnson (1996), Koivula and Kammerling (1990a,b), Liddicoat (1963, 1967), Low et al. (1972), Mason (1997, 1998), Mayerson (2001), Moses et al. (1998), Pinet et al. (1992), Rosenholtz and Smith (1950), Sabatier (1953), Sikes et al. (2000), Vo-Thanh and Hung (1985), Walker (1985).

Special attention: fragile, dye, coatings

6.1.16. Chalcedony

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Chelsea Colour Filter	
Spectroscope	Green variety
EDXRF chemistry	Green variety
Raman spectroscopy	If other tests are inconclusive

References

Carr and Fyfe (1958), Cassedanne (1982b), Crowningshield, (1964, 1967, 1969, 1970, 1973, 1975), Du toit (1997), Fryer (1986, 1987, 1988, 1989a,b, 1991, 1997), Guman, 1976, Halford-Watkins (1941), Hänni et al. (2001), Heflik et al. (1993), Hyrsl (1999), Ibragimov (1996), James (1994), Jayaraman (1953), Jobbins (1981), Johnson and Koivula (1996, 1998a,b, 1999), Jones (1952), Kammerling and Koivula (1991), Koivula (1986), Koivula and Fritsch (1993a,b), Koivula and Johnson (1996a,b), Koivula and Kammerling (1989, 1990a,b,c, 1992a,b), Koivula et al. (1992c), Liddicoat (1965a,b, 1966, 1967a,b), McLean (1967), Nuckles (1984), Pabian (1980), Pelto (1956), Sax (1996), Shaub (1979), Shigley and Koivula (1985), Spendlove (1987), Sukow (1987, 1990), Webster (1971), Willing and Stöcklmayer (2003)

Special attention: dye

6.1.17. Charoite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	

References

Akimov (1991), Bennett (1992), Biryukov and Bernikov (1993), Chikayama (1981), Demenge (1994), Dobrovolksya et al. (1980), Evdokimov (1995), Greenspan (1978), Jobbins et al. (1978), Johnson et al. (1999), Koivula and Fritsch (1993), Koivula et al. (1992), Konev et al. (1993), Kraeff et al. (1980), Lazebnik and Nikishova (1992).

6.1.18. Chrysoberyl

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye (colour change (alexandrite cat's-eye)
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Spectroscope	
FTIR(-NIR)	
Raman spectroscopy	If other tests are inconclusive
Colour call	In case of potential colour change
Clarity enhancement check/extent	

References

Anonymous (1997, 1998), Bank et al. (1997a, 1988c), Bergman (1997), Brown (1985), Cassedanne (1984a,b), Cassedanne and Roditi (1993), Crowningshield (1980b,c), DeMaggio (1997), Dillon (1983), Downes and Bevan (2002), Farn (1978), Fryer (1983b, 1989, 1990), Hayashi (1994), Henn (1985, 1987, 1992, 1994, 1995), Horn (1987), Isogami et al (1986), Jarrell (1997), Johnson and Koivula (1996, 1997a,b,c,d,e, 1999), Jones (1996), Koivula (1984a,b,c), Koivula and Fritsch (1993c), Koivula and Kammerling (1988c, 1989b, 1991a,b, 1992a), Liyanage (1997), Loock (1987), McLean (1997), Moses et al. (1998), Nassau (1980, 1987, 1990), Nassau and Nassau (1980), Ohguchi (1981), Okrusch (1971), Ouyang (1997), Panjikar and Ramchandran (1997b), Pinet et al. (1992), Proctor (1988), Scarratt (1994), Schmetzer (1985a), Schmetzer (1985a,b), Solntsev et al. (2004), Soman and Nair (1985), Tang and Sun (1998), Zoysa (1987)

Special attention: irradiation, synthetics

6.1.19. Chrysocolla

Required Test method	*Remark*
Microscope	
Phenomena	Within other minerals
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
UV-Visible(-NIR) spectroscopy	
EDXRF chemistry	
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive

References

Bracewell and Brown (1984), Einfalt and Sujatmiko (2006), Jones (1979), Koivula and Fritsch (1994), Koivula and Johnson (1996), Koivula and Kammerling (1992), Liddicoat (1969), McCondra (1998), Robertson (1981), Shen et al. (2006), Sun (1963), Zwaan (2015d)

Special attention: dyed (with Cu)

6.1.20. Clinohumite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	

Hydrostatic weighing (specific gravity)	
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive

References

Anderson (1983), Bank (1983), Bank et al. (1990), Choudhary and Golecha (2007), Dungler (1991), Friedrich et al. (2001), Fryer (1986, 1988), Fujino and Takéuchi (1978), Gaspar (1992), Heinrich (193), Henn et al. (2001), Jones (1969), Jones et al. (1969), Kocman and Rucklidge (1973), Koivula and Kammerling (1991), Koivula et al. (1988), Kolesnikova (1980), Langer et al. (2002), Larsen (1928), Mitchell (1978), Ribbe (1979), Robinson et al. (1973), Scarratt (1984), White and Hyde (1982)

6.1.21. Danburite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Long-wave UV fluorescence	
Raman spectroscopy	If other tests are inconclusive

References

Anderson and Payne (1939), Bank (1982), Cook (2003), Crowningshield (1960a,b,c,d, 1963), Dharmaratne (1999, 2002), Fryer (1986), Holzhey (1998), Hyrsl (1997), Johnson and Koivula (1998), Koivula (1984), Koivula and Kammerling (1992)

6.1.22. Diamond (colourless) — identification only

Required Test method	*Remark*
Microscope	
Spectroscope	
Polariscope	
Long-wave UV fluorescence	
Long-wave UV phosphorescence	
Short-wave UV fluorescence	
Short-wave UV phosphorescence	
Diamondview	Possibly synthetic
FTIR(-NIR) spectroscopy	
EDXRF chemistry	As needed
PL spectroscopy	

References

Anthony et al. (2002), Chalain (1995), Chalain et al. (1999, 2000a,b), Collins (2001a,b, 2003), Collins and Dahwich (2003, 2004), Collins et al. (2000), Collins and Ly (2002), Davies et al. (2007), De Weerdt (2001a,b), De Weerdt and Collins (2003), De Weerdt et al. (2004), De Weerdt and Van Royen (2000a,b), Diamond (1995), Dunaigre (1996), Erel (2007), Fizgeer et al. (2001), Fritsch et al. (2001), Frunze et al. (2000), Fryer (1997), Gippius et al (2003), Grampp (1999), Hemley et al. (2006), Horikawa (2001), Hunt et al. (2000), Iakoubovski (2006), Johnson and Kammerling (1995), Johnson and Koivula (1999), Jungnickel et al. (1996), Kammerling and Fryer (1995b,c), Kammerling and Koivula (1995e), Kammerling et al. (1995f,g,h, 1996), Kiefert et al. (2000), Kiflawi et al. (1997), King et al. 2008; King et al. 2006; Koivula and Fritsch (1995), Kupriyanov et al. (2008), Linares and Doering (2007a), Maeta et al. (2006), Maitrallet (1996), Maki et al. (2007), Manfredotti et al. (2006, 2007), Mankelevich et al. (2008), Marcczewska et al. (2007), May et al. (2008b), McClure (2000), McClure et al. 2000; McClure and Kammerling (1995),

Meguro et al (2006), Moses et al. (1997a,b,c 1998a,b,c, 1999, 2004), Nelson (1995), Nesladek et al. (2008), Neves et al. (1999), Newton et al. (2002), Novikov et al. (2003), Prins (2001, 2003), Qi et al (2001), Qian et al (2001), Scarratt and Shor (2006), Schmetzer (1999, 2000, 2001, 2002), Shuster (1998), Van Bockstael (1996), Yan (1998).

Special attention: irradiation, HP-HT, coatings, clarity enhancement, synthetics For diamond grading, see the PAS document

6.1.23. Diamond (coloured)

Required Test method	*Remark*
Microscope	
Polariscope	
Long-wave UV fluorescence	
Long-wave UV phosphorescence	
Diamondview	
UV-Visible(-NIR) spectroscopy	Low temperature
FTIR(-NIR) spectroscopy	
EDXRF chemistry	As needed
PL spectroscopy	
Geiger counter	Green and black diamonds
Clarity enhancement check	

References
Anonymous 1992; Achard et al. (2007a), Allers et al. (1998), Amosov et al. (2000), Barberini et al. (2000), Barnard (2000), Bosshart (1999), Bosshart and Smith (2001), Brauner (2007), Chalain (1995, 2003), Chalain et al. (1999, 2000a), Chao et al. (2007), Charles et al. (2003), Choi et al. 2009; Collins (2001a,b, 2003), Collins and Dahwich (2003, 2004), Collins et al. (2000), Collins and Ly (2002), Davies et al. (2007), De Weerdt (2001a), De Weerdt and Van Royen (2000a,b), Diamond (1995), Dutov et al. (2003), Edmonds et al. (2008), Ekomov et al. (2006), Fritsch et al. (2001), Fritsch et al. 2007a; Fritsch et al. 2007b; Fritsch et al. 2007c; Fryer (1992c, 1997), Gaillou et al. 2010; Grampp (1999), Hainschwang et al. 2005a,b; Hainschwang and Notari 2011; Hainschwang et al. 2006; Hainschwang et al. 2008; Hainschwang et al. 2009; Henn and Bank 1992b; Hodgkinson (2000), Horikawa (2001), Johnson and Kammerling (1995), Johnson and Koivula (1997, 1999), Kammerling and Fryer (1995b,c,d), Kammerling and Koivula (1995e), Kammerling et al. (1990, 1995a,f,h,i, 1996), Karkin et al., (2008), Katrussha et al. (2004a,b), Kiefert et al. (2000), Kiflawi et al (1997), King 1991; King et al. (1994, 1995, 1998, 2002, 2003, 2005), Koivula and Fritsch (1995), Lason et al. (1996), Liddicoat 1972c, 1975a; Linares (2006), Maitrallet (1996), Marinelli et al. (2006), Massi et al. 2005; May et al (2008b), McClure (2000), McClure and Kammerling (1995), Mita (1996), Moses et al. (1997a,b, 1998a,b,c, 1999, 2002), Notari 2002; Sautter et al. 2010; Scandella 1989; Scarratt (2001), Schmetzer (1999, 2000), Shida (1998a,b), Van Bockstael and Joppen (1996), Van Bockstael (1998a, 1996), VanderBogert et al. 2009; Vins (2002a,b), Vins and Konokov (2003), Titkov et al. 2003; Willems et al. 2004; Williams et al. 2002; Yamamoto et al. (1995), Yuan (1998), Zaiser et al. (2000), Zaitsev (2008), Zakharov et al. (1997)

Special attention: HP-HT, coatings, clarity enhancement, synthetics

6.1.24. Diaspore

Required Test method	*Remark*
Microscope	
Phenomena	Colour-change
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Spectroscope	

FTIR	If other tests are inconclusive
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive
Colour call	Colour change

References

Bank (1981), Bariac (1979), Baric (1963), Duroc-Danner (1987), Fryer (1983, 1987), Gosse (1962), Gout and Verdes (1992), Koivula (1985), Koivula and Fritsch (1994, 1995), Ruan et al (2001), Scarratt (1980), Schmetzer (1987), Schmetzer and Bartelke (1979), Wight (1997)

6.1.25. Diopside

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye, star
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Spectroscope	
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive

References

Anderson (1978), Andrut et al. (2007), Bank (1972, 1976, 1977, 1987), Bank et al. (1996), Bromiley et al. (2004), Calrk (1957), Crowningshield (1960, 1962, 1963a,b, 1964a,b, 1965), Eppler (1967), Field (1948), Fryer (1984), Gadiyatov (1996), Gasparik (1990), Gübelin (1981), Hänni et al (1996), Hietanen (1971), Ito (1987), Jackson (1985), Kammerling and Fryer (1994), Kent and Webster (1973), Koivula and Johnson (1996), Koivula and Kammerling (1989, 1990, 1992a), Koivula et al. (1992b), Liddicoat (1965a,b, 1972, 1973), Naito (1990), Nimis (1998), Ponahlo (1968), Robinson (1973), Schmetzer (1978), Schmetzer (1982), Schmetzer and Krupp (1979a), Schmetzer and Medenbach (1974), Schmetzer and Ottemann (1979b), Schrader (1984, 1985), Schramm (1987), Schreiber (1977), Skogby et al. (1990), White and Keester (1966), White et al. (1971), Wight (1990)

6.1.26. Dioptase

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Spectroscope	
EDXRF chemistry	If other tests are inconclusive
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive

References

Bank et al. (1990), Breuer and Eysel (1988), Breuer et al. (1989), Cook (2002), Crowningshield (1960), Eysel and Breuer (1981), Galbraith and Kuhn (1940), Gebhard (1982), Heide et al. (1955), Lhoest et al. (1991), Palfi (2005), Ribbe et al. (1977), Schubnel (1992)

6.1.27. Dolomite

Required Test method	*Remark*

Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
FTIR(-NIR) spectroscopy	
EDXRF chemistry	If other tests are inconclusive
Raman spectroscopy	
XRD	If other tests are inconclusive

References

Barber and Wenk (1979), Chai and Navrotsky (1996), Douglas (1999), Fryer (1992), Gauthier and Delines (1999), Gem trade lab notes (1998), Koivula and Fritsch (1994), Medlin (1959), Moses et al. (1998), Pinet et al. 1992), Searl (1989)

Special attention: dye

6.1.28. Dumortierite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	
XRD	If other tests are inconclusive

References

Alexander et al. (1986), Applin and Hicks (1987), Bank (1979), Beukes et al. (1987), Cassedanne and Franco (1966), Conwingshield (1964), Goreva eta l. (2001), Koivula et al. (1992), Ostwald (1964)

6.1.29. Ekanite

Required Test method	*Remark*
Geiger counter or dosimeter (µS/h)	
Safe storage	
Microscope	
Phenomena	Star
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	
XRD	If other tests are inconclusive

References

Anderson (1974), Arps (1987), Bank (1981a,b), Bank et al. (1989), Chikayama (1981), Deen (1984), Dharmaratne (1998), Fryer (1986), Gauthier and Fumey (1988), Gübelin (1961, 1962a,b, 1964), Johnson et al. (1999), Koivula and Kammerling (1988), Liddicoat (1962b, 1977), Mitchell (1961)

Special attention: radioactive

6.1.30. Emerald

Required Test method	*Remark*
Microscope	
Phenomena	Star, Cat's-eye, trapiche
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	If loose and other tests inconclusive
Chelsea colour filter	
Spectroscope	
Long-wave UV fluorescence	
UV-Visible(-NIR) spectroscopy	Origin
FTIR(-NIR) spectroscopy	Synthetic/natural and filler ID
EDXRF chemistry	Origin
Raman spectroscopy	Only for filler ID
LA-ICP-MS spectroscopy	If necessary for origin
Colour call	
Clarity enhancement check/extent	

References

Amstutz and Bank (1977), Anderson (1935, 1950, 1966, 1969, 1976, 1978), Attanasio et al. (1989), Bank (1960, 1964, 1969, 1973, 1974a,b,c, 1976, 1980, 1981b,c, 1982, 1989), Bank and Henn (1989a, 1990a), Bank et al. (1989b), Bastos (1981), Becker (1991), Benson (1959), Bosshart (1990a,b, 1991a,b,c,d), Bowersox et al. (1991), Bowersox and Anwar (1989), Briggs (1935), Brown (1984), Brown et al. (1989), Brown and Snow (1984, 1988), Calligaro et al. (2000), Cambell (1973, 1974, 1978, 1991), Caplan (1968), Carbonnel (1976), Cassedanne (1972, 1985), Cassedanne and Cassedanne (1974), Cassedanne and Sauer (1982, 1984), Chatham (1982), Clements (1941), Cook (2007), Cotton (1970), Crowningshield (1958, 1961a,b, 1964a,b,c,d,e, 1965a,b,c, 1967a,c, 1968, 1970b,c,d,e, 1971a,b, 1972a,b, 1974, 1980), Devouard (1990), Diehl (1977), Dillon (1981), Draper (1963), Duyk (1963, 1965), Eppler (1958, 1960, 1961, 1962, 1963, 1968), Epstein (1989), Farn (1964, 1980), Fryer (1981b,c,d, 1982a,b,c,d,e,f, 1983a,b, 1984b,c,d, 1988, 1989, 1990a,b, 1991), Fryer et al. (1983), Giuliani et al. (1990a,b), Graindorge (1974), Graziani et al. (1983), Graziani and Lucchesi (1979), Griesbach (1892), Groat et al. (2008), Grubessi et al. (1990), Gübelin and Shipley (1941), Gübelin (1940, 1941, 1944, 1947, 1950, 1956a,b, 1958a,b,c, 1959, 1960, 1961, 1962, 1964a,b, 1968, 1974, 1976, 1981a,b, 1982a,b, 1984), Gübelin and Chudoba (1956), Gübelinand Gysler-Sanz (1991), Hänni (1981, 1982, 1983, 1988), Hänni and Kerez (1983a), Hänni and Klein (1982, 1983b), Henderson (1945), Henn (1988), Henn and Bank (1991), Henn et al. (1984), Hodgkinson (1988), Holmes and Crowningshield (1960), Hosaka (1990), Johnson (1959, 1961a,b), Kammerling and Koivula (1990, 1991a), Kammerling et al. (1991b), Kane (1979, 1980a,b), Kane et al. (1989), Kanis et al. (1991), Kazmi and Snee (1989), Keeling (1991), Keller (1981), Koivula (1982, 1984a,b,c), Koivula and Kammerling (1988, 1989b,c,d,e, 1990a,b,c,d,e, 1991a,b,c,d,e,f), Koivula et al. (1990f), Lefever et al. (1962), Liddicoat (1963, 1964a,b,c, 1965b,c,d, 1967a,b, 1968, 1969a,b,d,e,f,g,h, 1970b,c,d,e,f, 1971b, 1972a,b, 1976, 1977b), Mac Fadden (1934), Mayers (1958a,b), McKague (1964), Metson and Taylor (1977), Mitchell (1981), Nassau (1977, 1980, 1981, 1982, 1990, 1991), Nassau and Jackson (1970), Nassau and Nassau (1980), O'Donoghue (1979, 1981, 1971, 1975), Oppenheim (1948), Pough (1965a,b, 1970, 1971), Rainier (1931), Ringsrud (1983, 1988), Robert et al. (1990), Rogers and Sperisen (1942), Scarratt (1984b, 1987a,b,c,d, 1988a,b, 1989a,b,c), Schlossmacher (1935), Schmetzer (1982, 1988a,b, 1989a,b, 1990a,b, 1991), Schmetzer and Bank (1980, 1981a, 1982), Schmetzer et al. (1981b,c, 1991, 2007), Schmetzer and Brezina (1975), Schmetzer and Kiefert (1990), Schmetzer and Krupp (1979), Schrader (1981, 1983, 1988a,b), Schubnel and Zarka (1971), Schwarz (1987, 1989a,b, 1990a,b,c, 1991a,b,c,d), Schwarz et al. (1988a,b,c,d, 1990), Schwarz and Eidt (1989), Seifert et al. (2004), Shipley (1942), Stockton (1984, 1987), Sunagawa (1964), Tenhagen (1972, 1973), Webster (1950, 1955, 1964), Wild (1935), Zwaan (2006), Zwaan et al. (2012, 2005, 2004, 2000, 1998, 1997)

Special attention: clarity enhancement (also cavity and wide fracture filling), synthetics, coating and dye

6.1.31. Enstatite

Required Test method	*Remark*
Microscope	
Phenomena	Star, Cat's-eye
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	If loose and other tests inconclusive
Spectroscope	
Raman spectroscopy	
XRD	If other tests inconclusive

References

Bank (1974, 1984), Beran and Zemann (1986), Crowningshield (1959, 1960, 1964, 1965a,b, 1967a,b), Dharmaratne (1998), Dunn (1978), Eppler (1967), Fryer (1984), Greer and Weber (1969), Harding et al. (1982), Koivula et al. (1988), Liddicoat (1962a,b, 1963), Mitchell (1952, 1954), Morimoto (1989), Schemter and Krupp (1982), Washington and Merwin (1923), Wehr et al. (2008), Zoysa (1985), Zwaan (1996)

6.1.32. Epidote

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	If loose and other tests inconclusive
Spectroscope	
Raman spectroscopy	If other tests inconclusive
XRD	If other tests inconclusive

References

Armbruster (2006), Bank (1976), Bank et al. (1989), Cook (2002), Crowningshield (1960, 1963), Dollase (1971), Fisher (1977), Fleet and Pan (1995), Grapes (1981), Griffith (1987), Gübelin (1979), Henn and Bank (1991), Hörmann and Raith (1971), Ito (1947), Janeczek and Sachanbinski (1992), Jimenez and Velilla (1993), Kumskova and Khvostova (1964), Langer and Raith (1974), Lapham (1957), Liddicoat (1963), Pinet et al. (1992), Pough (1965), Seemann (1986), Seki (1959), Wehr et al. (2008).

6.1.33. Feldspar – orthoclase, moonstone, microcline, albite, oligoclase, bytownite

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye, adularescence, aventurescence
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	If loose and other tests inconclusive
EDXRF chemistry	
LA-ICP-MS or SEM-EDS chemistry	If needed for variety separation
Raman spectroscopy	If other tests inconclusive
XRD	If other tests inconclusive

References
Bank (1967, 1973a,b, 1974), Bank and Henn (1989a), Barth (1934, 1931,1965b), Bassett (1953), Boyd and Wight (1981), Bracewell and Brown (1985), Bridges et al. (1984, 1989), Brown (1984), Brown and Bracewell (1985), Chalmers (1972), Clewlow (1977), Copley and Gay (1982), Crowningshield (1960, 1962b, 1963b,c, 1964a,b), Fenn (1977), Foster (1955), Fryer (1985, 1991), Gübelin (1987, 1992a), Hofmeister and Rossmann (1985a,b,c, 1986), Koivula (1986a,b, 1987a), Koivula and Kammerling (1988, 1989a, 1990a,b), Liddicoat (1963a, 1964, 1967), Raman and Jayaraman (1950a), Raman et al. (1950b), Umegaki (1966), Vance (1961), Webster (1949, 1952), Zoysa (1985)

6.1.34. Feldspar – labradorite, andesine

Required Test method	*Remark*
Microscope	
Phenomena	Labradorescence, aventurescence
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	If loose and other tests inconclusive
EDXRF chemistry	
LA-ICP-MS chemistry	
Raman spectroscopy	If other tests inconclusive
XRD	If other tests inconclusive

References
http://www.giathai.net/Red_Feldspar_Special_Report.php, http://www.gia.edu/research-resources/news-from-research/index.html, Bank and Henn (1989a), Bank et al. (1988, 1989b), Fontaine et al. (2010), Henn (2005), Liddicoat (1967a,b), Muir (1955), Rossmann (2011)

Special attention: heat, Cu-diffusion

6.1.35. Fluorite

Required Test method	*Remark*
Microscope	
Phenomena	Colour-change
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	If loose and other tests inconclusive
Polariscope	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
Raman spectroscopy	If other tests inconclusive
XRD	If other tests inconclusive

References
Allen (1952), Appiani (2007), Bank et al. (1996, 1989), Bariand (1986), Baumer et al. (1990), Berman (1957), Bill and Calas (1978), Bill et al. (1967), Blasse and Dirksen (1980), Bontinck (1958), Calas (1972b), Crowningshield (1962a,b, 1968), Duyk (1971), Elwell (1988), Fisher (2004), Forster (1995), Fryer (1985), Gübelin and Koivula (1987), Gübelin and Schmetzer (1980), Henn (2002), Hyrsl and Milisenda (2003), Kammerling and koivula (1991), Koivula and Elen (1998), Koivual and Fritsch (1995), Koivula and Kammerling (1993c, 1990), Liddicoat (1970a,c, 1972), Lieber (1994), Linley-Shaw (1975), MacFall (1982), Moroshinkin (1996), O'Donoghue (1978), Pinet et al. (1992), Redmann et al. (1990), Robbins (1996), Schmetzer and Bank (1980), Zwaan (2014c)

Special attention: fragile, easy cleavage

6.1.36. Forsterite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
dichroscope	
spectroscope	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
FTIR(-NIR) spectroscopy	
EDXRF chemistry	
Raman spectroscopy	

References

Basso et al. (1980), Benstock et al. (1997), Bershov et al. (1983), Chopelas (1991), Duffy et al (1995), Durben et al. (1993), Fan et al. (2007), Ferry (2001), Francis (1985), Francis and Ribbe (1980), Freund et al. (1980), Gaite and Hafner (1984), Gasparik and Litvin (1997), Green and Walker (1985), Henn (1999), Hofmeister (1987), Iishi (1978), Imae et al. (1993), Jaoul et al. (1979), Johnson and Koivula (1999), Jordan and Naughton (1964), Kanazawa et al. (2007), Koivula and Fryer (1990), Libowitzky and Beran (1995), Liu (1987), Luttge et al. (1992), Martin et al. (1992), Mohanan et al. (1993), Morin et al. (1977), Mossman and Pawson (1976), Nassau (1994), Rager (1977), Rager et al. (1988), Rao et al. (1987), Shankland and Hemmenway (1963), Smyth and Tafto (1982), Stebbins (1996), Steele et al. (1985), Wang et al. (1993), Weeks et al. (1974), Wentzcovitch and Stixrude (1997), Zambonini and Garobbi (1932)

Special attention: synthetic

6.1.37. Gahnospinel

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	May be outside upper range
Hydrostatic weighing (specific gravity)	
EDXRF chemistry	
Raman spectroscopy	
XRD	If other tests are inconclusive

References

Anderson (1964, 1974), Anderson and Payne (1938), Bank (1983), Burford (1997), Crowningshield (1963), Flinter (1963), Frenzel et al. (1986), Schmetzer and Bank (1985a,b, 1986), Schmetzer et al. (1989), Zoysa (1995)

6.1.38. Garnet – Pyrope, Almandine, Spessartine, Grossular (hessonite, tsavorite), Andradite (demantoid), Uvarovite

Required Test method	*Remark*
Microscope	
Phenomena	Colour-change, star
Refractometer (refractive index)	May be outside upper range
Hydrostatic weighing (specific gravity)	
EDXRF chemistry	

Raman spectroscopy	
XRD	If other tests are inconclusive

References

Agee (1965), Anderson (1945, 1946, 1947, 1959), Benson (1960), Crowingshield (1960, 1963a,b, 1964, 1966, 1967, 1969a,b,c,d, 1970a,b,c,d), Eliezri and Almor (1996), Gübelin (1945), Hidden and Pratt (1898), Hummel (1950), Ingerson and Barksdale (1943), Johnson and Koivula (1998a,b, 1999a), Johnson et al. (1999b,c,d), Koivula and Fritsch (1995), Lee (1962), Liddicoat (1966, 1967a,b, 1970), Manning (1967), Manson and Stockton (1982), Martin (1970), Pezzotta et al. (2011), Stephenson and Kouznetsov (2009), Webster (1963), Zwaan (2014a).

Special attention: heat treatment (demantoid)

6.1.39. Gypsum

Required Test method	*Remark*
Microscope	
Phenomena	Satin spar, cat's-eye
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	
XRD	If other tests are inconclusive

References

Bosbach et al. (1994, 1995), Cody and Cody (1989), Crowningshield (1960, 1963), Iishi (1979), Kondo and Ahrens (1983), Mann et al. (1993), Pinet et al. (1992), Robbins (1996), Sasowsky (1998), Zeitner (1980)

Special attention: soft material, easy cleavage

6.1.40. Hauyn

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Long-wave UV fluorescence	
Raman spectroscopy	
XRD	If other tests are inconclusive

References

Barth (1932), Hassan and Grundy (1989b, 1991), Henderson et al. (2000), Henn and Bank (1990), Jahn (2007), Linde (1998), Mertens (1984), Scarratt (1986)

6.1.41. Hematite

Required Test method	*Remark*
Microscope	
Magnet (magnetic reaction)	
Hydrostatic weighing (specific gravity)	
EDXRF chemistry	

Raman spectroscopy	
XRD	If other tests are inconclusive

References

Dietrich and Saadi (1969), Fryer (1984), Koivula and Fritsch (1993, 1995a), Koivula and Kammerling (1991), Lu and Sunagawa (1987), Mappin (1946), Ogawa et al. (1999), Pinet et al. (1992), Scarratt (1985a,b), Schmetzer and Bank (1984a)

Special attention: various imitations, non-magnetic and magnetic. It may not be possible to separate from manufactured material.

6.1.42. Idocrase (Vesuvianite)

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Spectroscope	
Raman spectroscopy	If other tests are inconclusive
XRD	If other tests are inconclusive

References

Allen and Burnham (1992), Arem (1973), Bank et al. (1989), Crowningshield (1960, 1965a,b, 1969b,c), Dillon (1983), Ito and Arem (1970), Koivula and Kammerling (1989, 1991), Liddicoat (1970), Scarratt (1986), Wight and Grice (1983)

6.1.43. Iolite (Cordierite)

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye, bloodshot
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Dichroscope	

References

Brown and Bracewell (1990), Dharmaratne (1999), Faye et al. (1968), Fryer (1982, 1991), Henn (1990), Johnson and Koivula (1998, 1999), Kammerling and Koivula (1991), Koivula and Fritsch (1993, 1995a,b), Koivula and Kammerling (1990, 1992), Liddicoat (1967), Pough (1987), Wight (1999b)

6.1.44. Jadeite – green, white, black, lavender

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	When possible
Chelsea colour filter	
Spectroscope	
Long-wave UV fluorescence	

FTIR(-NIR) spectroscopy	
EDXRF chemistry	
Raman spectroscopy	

References

Adams (1953), Albright (1981), Anderson (1871), Barber (1954), Battesti and Schubnel (1993), Bauer (1895, 1896), Bergstein (1964), Bishop (1906), Bleeck (1908), Brown (1993a), Cavey (1987), Chuanyi et al. (1988), Crowningshield (1957, 1959, 1961, 1962a,b, 1963a,b,c,d, 1964, 1972, 1973a, 1974), Deer et al. (1963, 1992), Desautels (1986), DeVries and Fleischer (1984), Ehrmann (1958a,b), Fritsch (1993a,b, 1994), Fritsch et al. (1993, 1992), Fryer (1983, 1984, 1985, 1986, 1987a,b, 1988a,b, 1989, 1992a,b, 1993, 1996a,b), Gübelin (1978), Halford-Watkins (1932), Harlow (1994), Healey and Yu (1983), Hertz (1912), Hobbs (1982), Hodgkinson (1993, 1996), Htein and Naing (1994, 1995), Johnson et al. (1995a,b), Kammerling and Fryer (1994a,b,c,d, 1995a,b,c,d,e), Kammerling and Koivula (1990a,b), Koivula (1982a,b), Koivula and Fritsch (1993, 1994), Koivula and Johnson (1996), Koivula and Kammerling (1989, 1990, 1991a,b), Koivula et al. (1992, 1995), Lasnier et al. (1992), Liddicoat (1963b,c, 1971, 1972, 1974, 1975c), Manaka (1994), Meen (1966), Mével and Kienast (1986), Mok (1993). Nassau and shigley (1987), Ou Yang (1993a,b, 1994, 1996c), Pough (1985), Prewitt and Burnham (1966), Rossman (1974), Scarratt (1986), Shida (1991), Ten (1989b), Yu et al. (1996).

Special attention: other jadeite-like minerals or rocks, omphacite, dye, resin, impregnation, wax, plastic coating

6.1.45. Jasper

Required Test method	*Remark*
Microscope	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	If other tests are inconclusive

References

Cassedanne (1971), Davidson (2000), Demenge (1994), Druzhinina (2000), Fritsch and Ivey (2015), Fryer (1989), Heflik et al. (1993), Henig and Collins (2001), Johnson and koivula (1999), Koivula and Johnson (1996), Rossman (1994)

6.1.46. Jeremejevite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	If other tests are inconclusive

References

Bank (1986), Bank and Becker (1977), Blass and Graf (1999), Chikayama (1981), de Ascencao-Guedes (2007), Foord and Cunningham (1978a), Foord et al. (1981), Foord and Mills (1978b), Herting and Strunz (1978), Hochleitner and Weiss (2000), Konovalenko et al. (1983), Künzel (1989), Kyi and Thu (2006), Liddicoat (1973a,b, 1976a,b), Liddicoat and Fryer (1974), Rondorf and Rondorf (1988), Stachowiak and Schreyer (1998), Strunz and Wilk (1974), Wilson et al. (2002), Zolotarev et al. (2000)

6.1.47. Kornerupine

Required Test method	*Remark*

Microscope	
Phenomena	Cat's eye
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	Small 2V angle
Raman spectroscopy	If other tests are inconclusive

References

Ackermand et al. (1984), Anderson (1974), Bank and Berdesinski (1974, 1975), Barot et al. (1995), Benson (1960), Crowningshield (1962a,b, 1965b, 1965c, 1974a,b, 1975a,b), Fryer (1982), Henn (1985), Koivula and Kammerling (1992a,b), Korevaar and Zwaan (1977), Liddicoat (1966), Moore and Bennett (1968), Payne (1954), Schmetzer (1978b), Schmetzer et al. (1978, 1979), Trumper (1949), Webster (1974), Zwaan (1992b)

6.1.48. Kyanite

Required Test method	*Remark*
Microscope	
Phenomena	Cat's eye, colour change
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Dichroscope	
Raman spectroscopy	If other tests are inconclusive

References

Barot et al. (1995), Bosshart et al. (1982), Chadwick and Rossmann (2009), Crowningshield (1959, 1966a,b), Delor and Leyreloup (1986), Ghera et al. (1986a, 1988), Gübelin and Schmetzer (1982), Hänni (1983), Hyrsl (1997), Hyrsl and Milisenda (1996), Ito (1986), Johnson and Koivula (1999), Key and Ochieng (1991), Langer and Abu-Eid (1977), Liddicoat (1973), Males (1974), Neiva (1984), Renfro and Shen (2013), Saul et al. (1991), Zwaan (2014b)

6.1.49. Lapis Lazuli

Required Test method	*Remark*
Microscope	Thermal reaction test, acetone
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Long-wave UV fluorescence	
Raman spectroscopy	Selective components
XRD	If other tests are inconclusive

References

Anderson (1954), Banerjee (1990), Bank (1970), Bank and Platen (1988), Bariand (1979), Bennett (1992), Brown (1985, 1993a,b), Crowningshield (1967a,b,c, 1974), Dillon (1981), Emmett (1985), Fryer (1981, 1982, 1983, 1985a,b, 1986a,b,c,d, 1988, 1989a, 1992, 1993), Heflik and Natkaniec-Nowak (2003), Johnson and Koivula (1998), Koivula and Fritsch (1993), Koivula and Kammerling (1988, 1991, 1992a), Koivula et al. (1992b,c), Liddicoat (1963a,b), Mitchell (1982), Mok (1991), Nassau (1980, 1982), Scarratt (1983, 1987), Schmetzer (1983, 1985), Webster (1958, 1971), Weerth (1994), Wyart et al. (1981)

Special attention: dye, coatings, impregnation, wax, 'synthetics', imitations

6.1.50. Magnesite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Long-wave UV fluorescence	
FTIR(-NIR) spectroscopy	
EDXRF chemistry	
Raman spectroscopy	
XRD	If other tests are inconclusive
References	
Bank et al. (1988a), Bank and Platen (1988b), Fryer (1985), Gillet (1993), Koivula (1986), Superchi (1997)	

Special attention: crystalline variety very soft, massive variety often used with dye

6.1.51. Malachite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
EDXRF chemistry	If other tests are inconclusive
Raman spectroscopy	
XRD	If other tests are inconclusive
References	
Balitsky and Bublikova (1990), Balitsky et al. (1987a,b), Bank et al. (1998), Bennett (1992), Chernenko and Melnikov (2003), Collyer et al. (1991), Cook (2001), Fedorov (2002), Fryer (1981), Goga (2000), Hen and scheider (1994), Hosaka (1990), Kammerling and Fryer (1994), Koivula and Fritsch (1995), Koivula and Kammerling (1989), Nassau (1990), Pinet et al. (1992), Strack (1996), Webster (1958)	

Special attention: reconstructed, impregnated, wax, synthetic

6.1.52. Maw-sit-sit

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	Selective components
References	
Anonymous (1997), Gübelin (1964-65), Gübelin (1965a,b,c, 1978), Lacroix (1930), Ou Yang (1984),	

6.1.53. Moldavite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
FTIR(-NIR) spectroscopy	
EDXRF chemistry	

References

Artemieva et al. (2002), Banerjee and Hager (1993), Blum and Chamberlain (1992), Bouska et al. (1985), Bouska and Rost (1972), de Goutiere (1995), Du Toit (1996), Frazier and Frazier (1991a,b), Horn (1985), Hrabanek and Malley (1988), Hurtig (2005), Koivula and Kammerling (1992), Konta and Saul (1976), Liddicoat (1975), Reban (1984), Rejl (1977), Saul (1987), Skalichy (1975), Trnka and Houzar (2002), Webster (1949), Zook (1974)

Special attention: artificial glass

6.1.54. Nephrite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	

References

Bancroft (1983), Bank (1975), Beck (1984), Crowningshield (1965), Fryer (1984), Kammerling and Fryer (1995), Koivula and Kammerling (1988), Liddicoat (1969), Nieder (1982), Ruff (1950), Sun (2005), Yarmack (1964)

Special attention: dye

6.1.55. Obsidian

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
FTIR(-NIR) spectroscopy	
EDXRF chemistry	

References

Acquafredda et al., 1999; Baugh and Nelson, 1987; Bavay et al., 2000; Bellot-Gurlet et al., 2008; Bellot-Gurlet et al., 2005; Bigazzi et al., 1992; Bigazzi et al., 1986; Biró, 2004; Bunney, 1985; Calligaro, 2008; Cohen, 1958; Craig et al., 2010; Craig et al., 2007; Crowningshield, 1975; Faulques et al., 2001; Glascock, 2002; Henn, 1995; Holzhey, 1996; Hughes, 1982; Hyrsl and Žáček, 1999; Johnson and Koivula, 1997, 1998; Kelloway et al., 2010; Koivula and Fritsch, 1993a, b; Miller, 2006; Millhauser et al., 2011; Moses et al., 1998; O'Keefe, 1984; Pereira et al., 2001; Poupeau et al., 2010; Rosen et al., 2005; Rozsa et al., 2006; Sheppard et al., 2011; Sinkankas, 1996; Spriggs et al., 2011; Webster, 1949; Weiner, 1983; Williams-Thorpe, 1995; Zook, 1973

Special attention: artificial glass

6.1.56. Opal

Required Test method	*Remark*
Microscope	
Phenomena	Play of colour, Cat's-eye (rare), Star (rare)
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
Long-wave UV fluorescence	
Long-wave UV phosphorescence	
Short-wave UV fluorescence	
Short-wave UV phosphorescence	
UV-Visible(-NIR) spectroscopy	If dye is suspected
FTIR(-NIR) spectroscopy	

References

Adamo et al. (2010), Adams et al (1991), Bardosova et al. (2003), Bartoli et al. (1990), Baryshev et al. (2002, 2003), Birdsall (1986), Brajkovic et al. (2007), Brown et al. (2003), Brown et al. (2004), Brown et al. (2002), Cady et al. (1996), caucia et al. (2009), Caucia et al. (2008), Chen et al. (2004), Clarke (2003), Davies (2005), Deelman (1986), de Jong et al. (1987), Einfalt (2007), Eliseev et al. (2009), Elzea et al. (1994), Elzea and Rice (1996), Erel et al. (2003), Esenli et al. (2001, 2003), Flörke et al. (1991), Fritsch et al. (2002, 2003, 2004, 2006), Gaillou et al. (2008a,b), Gauthier et al. (2004), Graetsch (1994), Graetsch et al. (1985, 1987, 1990,1994), Guthrie et al. (1995), Harder (1995), Hatipoglu (2009), Heylmun (1987), Holgado et al. (1999), Hoover et al. (1996), Horton (2002), Ilieva et al. (2007), Kalinin et al. (1998, 2002, 2003, 2004), Kalinin and Serdobintseva (2003), Karpov et al. (2005), Kavtreva et al. (2007), Kuznetsova et al. (2003), Li et al. (1994), Livstrand (1987), Mazzero et al. (2010), McOrist and Smallwood (1997), Meseguer et al. (2002), Nagase and Akizuki (1997), Nassau (1989), Ni et al. (2001), Ostroumov (2007), Ostrooumov et al. (1999), Ostrooumov and Talay (2000), Palacios-Lidon et al. (2005), Paris et al. (2007), Pearson (1985), Pechar (1985), Pecover (2007), Pewkliang et al. (2008), Potapov and Kamashev (2006), Rice et al. (1995), Rondeau et al. (2004), Rondeau et al. (2010), Salgueirino-Maceira et al. (2003), Schellnegger (2002), Senior (1996), Serdobintseva and Kalinin (2000, 2001), Simonton et al. (1986), Smallwood (1997), Smallwood et al. (1997a,b), Thomas et al. (2006, 2007, 2008), Viti and Gemmi (2009), Vysotsky et al. (2010), Webb and Finlayson (1987), Williams and Crerar (1985), Williams et al. (1985), Wollaert et al. (1990), Zwaan (2015b)

Special attention: sugar and smoke treatments, dye, impregnation, synthetics

6.1.57. Pectolite

Required Test method	*Remark*
Microscope	
Phenomena	Cat's eye (rare)
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Long-wave UV fluorescence	
Long-wave UV phosphorescence	
Short-wave UV fluorescence	
Short-wave UV phosphorescence	
EDXRF chemistry	
Raman spectroscopy	If other tests are inconclusive

References
Anderson 1989; Bank et al. 2000; Bente et al. 1991; Dunn 1978; Fuetes Marcuello and Garcia Guinea 1990; Koivula 1986b, a; Koivula and Kammerling 1990, 1992; Koivula et al. 1992; Liddicoat 1976a, b; Liebau 1980; Lizzadro 1987; Peacock 1935; Pough 1997; Schaller 1955; Schmetzer 1984; Steiner 1996; Sullasi et al. 2010; Vaughan et al. 1921; Woodruff 1986, 1987; Woodruff and Fritsch 1989

6.1.58. Peridot

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Spectroscope	

References
Aboosally 1999; Adamo et al. 2009; Agrell et al. 1998; Austin 1991; Bancroft 1981; Bank 1995; Bank et al. 1994; Beard 1995; Benson 1960; Bocchio et al. 1986; Braunwart 1993; Brown and Bracewell 1982; Burford and Gunasekara 2000; Crowningshield 1962, 1973, 1975b; Cruse 2007; Dick 1993; Dill et al. 2006; Dillon 1981; Drucker 1998; Dupuy et al. 1991; Dyar et al. 1998; Dyar et al. 2009; Eppler 1960; Fan et al. 2007; Farrell and Newnham 1965; Federman 1995; Fischer 1985; Frazier and Frazier 1992, 1997; Fryer 1987; Fuhrbach 1992, 1997, 1998; Gübelin 1980, 1981a, b, 1986; Gübelin and Peretti 1996; Gunawardene 1985; Henn 1999; Henn et al. 1994; Henn and Becker 1992; Henn and Milisenda 1997; Hyrsl 2011; Kammerling et al. 1995; Kammerling and Koivula 1991, 1995a, b; Kammerling et al. 1994; Kanazawa et al. 2007; Kane 2004; Koivula 1980, 1981, 1992; Koivula and Fritsch 1993b, d, e, f, 1994a, b, c, d; Koivula and Fryer 1986, 1987; Koivula and Kammerling 1990b, 1991, 1992b; Koivula et al. 1995; Kurat et al. 1982; Leelawathanasuk et al. 2011; Lepold and Schramm 1989; Libowitzky and Beran 1995; Liddicoat 1968, 1969, 1970a, b; Lieber 1976; Mao 1990; Mattice 1995; Milisenda et al. 1995; Moses et al. 1999; Mouri and Enami 2008; Nassau 1994; Peretti and Gubelin 1996; Poeter 1999; Pough 1986, 1997b; Sinkankas et al. 1992; Snee and Ahrens 1975; Sokolov et al. 2002; Stockton and Manson 1983; Taylor 1971; Van Pelt 1938; Walmstedt 1825; Webb 1993; Wilson et al. 1974; Wilson 2007; Wilson 1976; Yang 1993; Zeitner 1990; Zolotaryov et al. 2003; Zook 1972

Special attention: may be damaged by acids

6.1.59. Petalite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
Raman spectroscopy	

References
Bank 1971; Cassedanne and Cassedanne 1978; Cerny and Ferguson 1972; Cerny and London 1983; Charoy et al. 2001; Crowningshield 1963; Fryer 1986; Heinrich 1975; Ito 1986; Karfunkel et al. 2002; Leal-Gomes and Dias 2009; Liddicoat 1976b; Lindner 1967; Nel 1946; Pough 1966, 1998; Selway et al. 2002; Wight 1990; Win and Themelis 2003; Zemann-Hedlik and Zemann 1955

6.1.60. Phenakite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing	

(specific gravity)	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
Raman spectroscopy	

References

Anonymous 1911, 1913; Balginina et al. 1988; Bank 1987, 1988; Bank et al. 1996; Bank et al. 1988; Barton 1986; Bastos 1972; Bayle 2010; Beran 1990; Billings 1927; Bulnaev 2006; Cario 1989; Cassedanne 1985; Chaves et al. 1998; Clark et al. 1986; Cook 2009; Crowningshield 1960, 1970; Dunn 1974; Gübelin 1979; Hazen and Au 1986; Hazen and Finger 1987; Hofmeister et al. 1987; Hyrsl and Quintens 1999; Jacobson 1979; Koivula and Fritsch 1994b, f; Lee and Erd 1963; Liddicoat 1963a, b, 1969b, c; Lottermoser 1986; Marcos-Pascual and Moreiras 1997; Melby and Taylor 1983; Niedermayr 1978; O'Donoghue 1976; Pinet et al. 1992; Pough 1935, 1936, 1966b, 1972, 1997c; Remeshilo and Vovk 1973; Shein et al. 2008; Spencer 1906, 1934; Tomaz-Filho et al. 2005; Tsinober et al. 1986

6.1.61. Phosphophyllite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Short-wave UV fluorescence	
EDXRF chemistry	
Raman spectroscopy	

References

Bank 1975; Fryer 1989; Hill 1977; Hyrsl and Petrov 1998; Kleber et al. 1961; Liddicoat 1969c, 1971; Pough 1997d; Wilson and Petrov 1999

6.1.62. Plastic

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
FTIR(-NIR) spectroscopy	

References

Alam and Stanton 1994; Anonymous 1958, 1959, 1980; Benson 1960b; Brown 1991, 1993; Bubshait and Sturman 1996; Chaki and Li 1984; Crowningshield 1964, 1969a, b, 1974; Evans and Crook 1997; Farn 1978; Foreman 1997; Foreman et al. 1996; Fryer 1981, 1983, 1984, 1985a, b, 1987a, 1989a, 1990, 1997; Gunawardene 1983; Gunawardene and Mertens 1983; Henn 2008; Hofmeister 1992; Horiuchi 1982; Hughes 1987; Hurwit 2002; Kammerling and Fryer 1995; Kammerling and Koivula 1989; Kammerling et al. 1995b; Koivula 1987; Koivula and Fritsch 1993c, 1995; Koivula and Kammerling 1988, 1989a, b, 1990c, 1991b, c; Koivula et al. 1992b, 1995a; Koivula et al. 1990; Liddicoat 1963a, 1966; Manson 1978; Mark 1984; Milisenda 1996; Nassau 1980, 1982, 1986; Ou Yang 1993; Scarratt 1981, 1984, 1987, 1992; Scarratt et al. 1993; Schmetzer and Bank 1983; Smith 1994; Tinney et al. 1996; Webster 1939, 1949b; Yost and Weidenhamer 2008

6.1.63. Prehnite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
Raman spectroscopy	

References

Akizuki 1987; Bank 1975a; Beattie and Brown 1985; Bracewell 1989; Brown and Snow 1981; Crowningshield 1963a, b; Currier and Pohl 2011; Howard 1997; Huber 1975; Liou 1971; Nazarova et al. 1990; Pan et al. 2009; Papike and Zoltai 1967; Pough 1966b, 1997e; Roger 1987; Rohn 1998; van Houten 1971

6.1.64. Pyrite

Required Test method	*Remark*
Microscope	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	
XRD	If other tests are inconclusive

References

Abraitis et al. 2004; Annamoe and Alpatov 2001; Bartlett 1997; Blount 1993; Buckley and Woods 1987; Costagliola et al. 1997; Craig and Vokes 1993; Craig et al. 1998; Descostes et al. 2004; Dódony et al. 1996; Frondel 1936; Fryer 1988; Gunawardene 1983b; Howie 1992; Hu et al. 2006; http://rruff.info/Marcasite; http://rruff.info/Pyrite, Hyde and O'Keeffe 1996; Johnson and Koivula 1997a; Karguppikar and Vedeshwar 1988; Koivula and Kammerling 1991b; Lennie and Vaughan 1992; Liddicoat 1972; Luther 1991; Moses and Herman 1991; Moses et al. 1987; Murowchick 1992; Murowchick and Barnes 1987; Nickel 1968, Pough 1996; Rimstidt and Vaughan 2003; Russell et al. 1990; Sawlowicz 1993; Schmetzer 1983; Wilkin and Barnes 1997; Zakrevskaya 1995; Zhu and Wadsworth 1994; Zilbershteyn 1985

Special attention: marcasite (misnomer), steel imitation

6.1.65. Quartz (amethyst, citrine, rock crystal, smoky, rose, aventurine, etc.)

Required Test method	*Remark*
Microscope	
Phenomena	Star
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	If loose
Polariscope	
Immersion	In water
Long-wave UV fluorescence	
Short-wave UV fluorescence	
FTIR(-NIR) spectroscopy	

References
Abdukadyrova (2004), Adekeye and Cohen (1986), Aines and Rossmann (1986), Antao et al. (2008), Bachheimer (2000), Bahadur (2006), Bailey (2001), Balitsky and Balitskaya (1986), Balitsky and Balitskaya (2009), Balitsky et al. (1998, 1999, 2000, 2001, 2004), Baran et al. (1987), Bettiol et al. (1997), Blatt H. (1987), Bons (2001), Botis et al. (2005), Bulur et al. (2000), Cassedanne and Roditi (1991), Cherniak et al. (2007), Cohen (1985), Cohen and Makar (1985), Commin-Fischer et al. (2009), Cordier and Doukhan (1991), Dedushenko et al. (2004), de Miranda-Pinto et al. (2011), Demars et al. (1996), Demazeau et al. (1994), Di Benedetto et al. (2009), Dolino (1990), Donaldson and Borm (1998), Donovan et al. (2011), Dotto and Isotani (1991), Duarte et al. (2011, 2009), Duttine et al. (2002), Epstein (1988), Ericksen (2001a,b), Farver and Yund (1991), Fast (2008), Ferreira de Souza (2010), Flem et al. (2002), Garland (2004), Gilg et al. (2003), Goreva and Rossman (2001), Götte et al. (2011), Götze (1997, 2009), Götze and Plötze (1997), Götze et al. (2001, 2004, 2005), Gunter (1999), Hartmann et al. (2010), Heaney and Veblen (1991a,b), Hebert and Rossman (2008), Henn and Güttler (2009), Hickel et al. (2000), Hyrsl (2006), Ihinger and Zink (2000), Iwasaki and Iwasaki (2002), Jaek et al. (2003), Karampelas et al. (2005), Kibar et al. (2007), Killingback (2008), Kronenberg (1994), Kurosawa et al. (2003), Landmann (1999), Landtwing and Pettke (2005), Lehmann et al. (2009), Lin et al. (1994), Lu and Sunagawa (1990), Lu et al. (1990), Ma et al. (2002), Manning (1994), Marko et al. (2006), Marler (1988), McArthur et al. (1993), McConnell (1995), Monecke et al. (2000), Moore (1986), Moore (2007), Morteani et al. (2010), Muller et al. (2003), Murray and Olley (2002), Muto et al. (2004), Neumann and Schmetzer (1985), Notari et al. (2001), Ontiveros et al. (2004), Ostapenko and Mitsyuk (2006), Owen (1988), Pagonis et al. (2010, 2011), Pan et al. (2008, 2009), Pankrath an Flörke (1994), Partlow and Cohen (1986), Paterson (1986), Perny et al. (1992), Philippot et al. (1996), Proust and Fontaine (2007a,b), Rakov (2003), Rakov and Krylova (2001), Rakov and Shuriga (2009), Ramseyer et al. (1988), Ream (1991), Richards (1990), Rosa et al. (2005), Rossman (1994), Rusk et al. (2011), Sawakuchi and Okuno (2005), Schmetzer (1987, 1988, 1989), Schmetzer and Glas (2003), Schmetzer and Krzemnicki (2006), Schultz-Güttler et al. (2008), Seifert et al. (2011), SivaRamaiah et al. (2011), Spicuzza et al. (1998), Stegger and Lehmann (1989), Stenina (2004), Stevens-Kalceff (2009), Subedi et al. (2011), Sunagawa (1999), Sunagawa and Balitsky (1990), Suzuki and Nakashima (1999), Swanson and Fenn (1986), Tajika and Hashimoto (2006), Thomas et al. (2000), Trossarelli (1985), Umari et al. (2001), Vasconcelos et al. (1994), Wenrich and Christensen (1996), White and Cook (1990), Wilson (1999), Wintle and Murray (1997), Zhang et al. (1994), Zolensky et al. (1988).

Special attention: synthetics, coatings, irradiation, heat treatment, dyed and impregnated (quartzite)

6.1.66. Rhodochrosite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	Upper limit outside range
Spectroscope	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
EDXRF chemistry	If other tests are inconclusive
Raman spectroscopy	If other tests are inconclusive

References
Auzat 1992; Bank 1975c; Bank and Becker 1977; Bartos et al. 2007; Birch 1986; Boettcher et al. 1992; Brusentsova et al. 2010; Cassedanne 1997, 1998; Cory 1991; Crowningshield 1962a; da Cunha 1993; de Brodtkorb and de Brodtkorb 1979; Dillon 1981a; Fedorov 2002; Frost et al. 2006; Galloni 1950; Hyrsl 1997, 2001; Jones 1997; Knox and Lees 1997; Koivula and Fritsch 1993h; Koivula and Kammerling 1990b; Kosnar 1979; Kuck and Saaid 1998; Lees et al. 1998; Liddicoat 1963d, 1967; Miller 1971; Petsch 1990; Pinet et al. 1992; Saadi 1988; Saadi and Carlos 1992; Sala et al. 1973; Schmetzer and Berdesinski 1974; Sinkankas 1955, 1977; Sutherland 1997; Sutthirat et al. 2011; Von Bezing et al. 1991; Wilson and Dunn 1978a, b; Zwaan 2015d

Special attention: easy cleavage single crystal material

6.1.67. Rhodonite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Spectroscope	
EDXRF chemistry	If other tests are inconclusive
Raman spectroscopy	If other tests are inconclusive

References

Millsteed 2006; Millsteed et al. 2005; Nelson and Griffen 2005; O'Neill 1986; Ohashi and Finger 1975; Ohashi et al. 1975; Paião and Watanabe 2008; Peacor and Niizeki 1963; Peacor et al. 1978; Pinet et al. 1992; Pirsson 1890; Pough 1966c; Sapountzis and Christofides 1982; Simandl et al. 2001; Smith et al. 1981; Suhner 1979; Takei and Hosoya 1985; Thurm 1973; Zhao et al. 1986; Zigovecki-Gobac et al. 2010

6.1.68. Ruby

Required Test method	*Remark*
Microscope	
Phenomena	Star
Immersion	Be diffusion, synthetic
Refractometer (refractive index)	
Spectroscope	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
DiamondView	Glass filling
UV-Visible(-NIR) spectroscopy	If necessary for origin
FTIR(-NIR) spectroscopy	
EDXRF chemistry	
LA-ICP-MS chemistry	Be test heated stones, if necessary for origin
Residue check and extent	Flux healing
Colour call	
Clarity enhancement check and extent	Glass filling

References

Abduriyim and Kitawaki 2008; Abduriyim et al. 2012; Achiwawanich et al. 2006; American Gemological Laboratories 1982a, b; Anderson 1980a, b; Anderson 1981; Arem 1987; Arkhangelskii et al. 1969; Arrouas 1993; Balmer et al. 2009; Bancroft 1988; Banerjee et al. 1985; Bank 1963, 1971b, 1974, 1975d, 1978; Bank et al. 1988a; Bank and Henn 1988, 1989; Bank et al. 1988b; Bank and Okrusch 1976; Barthem et al. 1982; Bassett 1997; Basun et al. 2007; Belt 1967; Berrangé and Jobbins 1976; Bessonova et al. 1981; Bessonova and Stanislavskii 1981; Bosshart 1982, 1983; Bosshart and Schmetzer 1986; Bowersox et al. 2000; Brown 1981, 1992a, b; Brown and Beatti 1992; Butcher and White 1964; Calligaro et al. 1998; Calligaro et al. 1999; Cartier 2011; Chaiwong et al. 2005; Chalain 1995; Christie Manson and Woods 1990; Clark 1992, 1993; Cockayne et al. 1969; Coenraads 1992; Coldham 2009; Cozar 1995; Crowningshield 1966, 1969b, 1974a; Currie 1988; Davison and Houghton 2007; Delé-Dubois et al. 1993; Dele et al. 1997; Devouard 1989; Dill 2005; Duroc-Danner 1988, 2002, 2003; Emmett et al. 2003; Emmett 1999; Frederic 1994; Fryer 1987c, 1992, 1996a, b, 1997b; Galia 1987; Galibert and Hughes 1995; Garcia-Lastra et al. 2005; Garnier et al. 2008; Garnier et al. 2002; Geisler 1976; Geranicheva et al. 1975; Giuliani et al. 2005; Giuliani et al. 2012; Grapes and Palmer 1996; Grapes and Hoskin 2004; Grubessi 1990; Grundmann and Morteani 1995; Gübelin 1966, 1979a, 1981a, 1982, 1985–86; Gübelin and Knischka 1980; Gunawardene 1984; Hager 2007; Hager et al. 2010; Hamid et al. 1999; Hänni 1992, 1993, 1994, 2001a, b; Hänni and Krzemnicki 2009; Hänni et al. 2001; Hänni and Schmetzer 1991; Hänni et al. 1994; Hänni and Stern 1982; Harding and Jobbins 1984; Harding and Scarratt 1986; Henn 1991, 1994; Henn and Bank 1991a, b, 1993a, b; Henn et al. 1990a; Henn et al. 1990b; Henn and Milisenda 1994; Hintze 2010; Hoang et al. 1999; Holzapfel

2003; Hughes and Galibert 1997; Hughes 1992, 1996a, b, 1997; Hughes and Galibert 1998; Inamori Jewelry Division 1980; Jobbins and Berrangé 1981; Johnson and Koivula 1997b, 1998a; Johnson et al. 1999a, b; Joseph et al. 2000; Kammerling et al. 1995a; Kammerling and Koivula 1994; Kammerling et al. 1995c; Kane 1983, 1985, 1997; Kane et al. 1991; Kawano 2009; Keller 1983; Kiefert and Schmetzer 1991; Kissin 1994; Knischka and Gübelin 1980; Koivula and Fritsch 1993b, i, 1994b, f, h, 1995a; Koivula and Johnson 1996; Koivula and Kammerling 1988a, c, 1991b, 1992b, c; Koivula et al. 1992a, b, 1995c; Koivula et al. 1995d; Krzemnicki 2011; Krzemnicki and Hänni 2008; Lee and Hoggard 1990; Leelawathanasuk-Pavaro et al. 2008; Leelawathanasuk et al. 2009; Leonyuk et al. 2005; Li et al. 2011; Liccardo et al. 2005; Liddicoat 1962, 1969d, 1970a; Linares 1965; Lu and Shigley 1998; McClure et al. 1993; McClure et al. 2006; Mercier et al. 1999; Milisenda et al. 2005; Muhlmeister et al. 1998; Mullenmeister and Zang 1995; Nassau 1969, 1981, 1990; Nguy et al. 2006; Oishi et al. 2004; Pardieu 2007; Pardieu et al. 2009; Peretti 1993; Peretti et al. 1995; Peretti and Smith 1993; Pham et al. 2004a; Pham et al. 2004b; Pongkrapan et al. 2010; Qi 1996; Qi et al. 1999; Rakontondrazafy et al. 2008; Ribeiro and Zanatta 2003; Saminpanya and Sutherland 2011; Sanchez et al. 2001; Sanchez et al. 1997; Scarratt 1985, 1994; Schmetzer 1985, 1986, 1999; Schmetzer and Peretti 1999; Schmetzer et al. 2009, 2010; Schmetzer and Schwarz 2007; Schwarz et al. 2008; Schwarz and Schmetzer 2001; Shida 1996; Smith 1992, 1995, 1996, 1998; Smith and Bosshart 1993; Smith et al. 1997; Sun 1992; Sun and Guang 1999; Sunagawa et al. 1999; Superchi and Rolandi 1980; Sutherland et al. 2009; Sutherland et al. 2006; Sutherland and Schwarz 2001; Syassen 2008; Tang et al. 1989; Teshima et al. 2005; Themelis 1992, 2003, 2005; Verneuil 1891, 1892, 1903; Wang et al. 2007; Wanthanachaisaeng et al. 2006; Webb 1997; Webster et al. 1939; Winotai et al. 2004; Winotai et al. 2000; Yui et al. 2008

Special attention: heat treatment, residues, diffusion, (lead) glass filling, dye, synthetics

6.1.69. Sapphire

Required Test method	*Remark*
Microscope	
Phenomena	Star, colour change
Immersion	Synthetic, Be diffusion
Refractometer (refractive index)	
Spectroscope	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
DiamondView	Glass filling
UV-Visible(-NIR) spectroscopy	Be diffusion, if necessary for origin
FTIR(-NIR) spectroscopy	
EDXRF chemistry	
LA-ICP-MS chemistry	Be test heated stones, if necessary for origin
Residue check and extent	Flux healing
Colour call	e.g., Padparadscha

References

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Special attention: heat treatment, diffusion, (lead, cobalt) glass filling, Synthetics

6.1.70. Sapphirine

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Dichroscope	
Raman spectroscopy	

References

Bank et al. 1989; Christy and Grew 2004; Deer et al. 1978; Francis and Matsueda 2004; Fryer 1985c, 1987c; Grew et al. 2008; Haapala et al. 1971; Harding and Zoysa 1990; Henn 2001; Horrocks 1983; Janardhanan and Leake 1974; Koivula 1996; Koivula and Fryer 1987b; Koivula and Kammerling 1988d; Langer et al. 1994; McColl and Warren 1984; McKie 1963; Moore 1969; Moses et al. 1998b; Ostwald 1964; Saul et al. 1991; Scarratt 1987b, c; Segnit 1957; Steffen et al.

1984; Su et al. 2012; Sutherland and Coenraads 1996; Wight 1990b; Wilson and Hudson 1967; Zeitner 1986; Zoysa 1995

6.1.71. Saussurite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	
References	
Jobbins and Rutland 1974; Scarratt 1987c, e	

6.1.72. Scapolite

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
FTIR(-NIR) spectroscopy	
Raman spectroscopy	If other results are inconclusive
References	
Antao and Hassan (2002, 2008a,b, 2011a,b), Antao et al. (2008), Baker (1994), Chamberlain et al. (1985), Comodi et al. (1990), Couper (1991), De Grave et al. (1986), Hassan and Buseck (1988), Hawthorne and Sokolova (2008), Hazen and Sharp (1988), Henn (2005), Moecher and Essene (1991), Moecher et al. (1994), Pan and Dong (2003), Seto et al. (2004), Sherriff et al. (1987, 1998, 2000), Sidike et al. (2008), Sokolova and Hawthorne (2008), Sokolova et al. (1996), Stolz (1987), Superchi et al. (2010), Teertstra and Sherriff (1996), Vassilikou-Dova (1991), Vochten et al. (1986), Zhang (1992), Zolotarev (1993), Zolotarev et al. (2003), Zwaan (1986, 1996)	

6.1.73. Serpentine – bowenite, williamsite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
FTIR(-NIR) spectroscopy	
Raman spectroscopy	
References	
Auzende et al. 2004; Baese et al. 2010; Bank and Berdesinski 1975; Baronnet and Devouard 1996; Brown and Bracewell 1995; Chen and Menu 2010; Choudhary 2011; Crowningshield 1959a, 1961b, c, 1962c, 1972, 1973b, 1975a; Dódony and Buseck 2004; Ferguson 1977; Fryer 1983b, 1987e; Groppo et al. 2006; Harlow and Sorensen 2005; Hoyer 1997; Johnson and Koivula 1998a; Kammerling and Fryer 1995a; Kammerling et al. 1991; Kammerling et al. 1995d; Kim 1998; Kim	

and Cho 1998; Koivula and Kammerling 1989a; Krstanovic 1997; Liddicoat 1962c, 1965, 1967b, 1972b; McMahon 1890; Miura et al. 2011; Schreur 1982; Segnit 1985; Wang and Zhang 2011; Webster 1958, 1967; Zalishchak et al. 2007; Zeitner 1980

Special attention: dye

6.1.74. Sinhalite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Polariscope	
Spectroscope	
FTIR(-NIR) spectroscopy	
Raman spectroscopy	If other tests are inconclusive

References
Anderson 1952a, b, 1974; Bank 1977; Bauernhansl and Beran 1997; Bowden et al. 1969; Claringbull and Hey 1952; Crowningshield 1958, 1960; Deen 1984; Dharmaratne 1998, 1999; Fang and Newnham 1965; Hayward et al. 1994; Henn 1985; Koivula and Fritsch 1993j; Liddicoat 1970d, 1976c; Moore et al. 1989; Payne 1952, 1958; Pinet et al. 1992; Pitman et al. 1995; Pough 1964; Werding et al. 1981; Wight 2000; Zeitner 1986; Zwaan 1955

6.1.75. Sillimanite

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
FTIR(-NIR) spectroscopy	
Raman spectroscopy	If other tests are inconclusive

References
(Althaus 1967; Bank 1974a; Bank et al. 1978a; Beran et al. 1983; Burnham 1963; Crowningshield 1957; Dharmaratne 1999; Fernandes 1993; Fleet and Arima 1985; Fryer 1981d, 1987b; Fyfe 1967; Gamini Zoysa 1985; Gübelin et al. 1986; Hanson 1956; Hayashi and Manaka 1994; Karanth et al. 1999; Kempe 1967; Koivula and Fritsch 1993d, 1994b; Mernagh and Liu 1991; Milisenda and Henn 2006; Pinet et al. 1992; Randriamanga 1994; Rossman et al. 1982; Saini et al. 1995; Scarratt 1986a, b; Spencer 1920; Yan et al. 1995; Zoysa 1995; Zwaan 1982

Special attention: single crystal has easy cleavage

6.1.76. Sodalite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Dichroscope	
Spectroscope	
Long-wave UV fluorescence	
Raman spectroscopy	

References
Anonymous 1824; Balassone et al. 2012; Ballentyne and Bye 1970; Ballirano et al. 1991; Bank 1974b; Brandstatter et al. 1997; Brousse et al. 1969; Brown 1998; Cano et al. 2010; Cassedanne and Cassedanne 1980; Denisov et al. 1977; Denks et al. 1974; Depmeier 2005; Field 1948; Fijal and Tokarz 1981; Frazier and Frazier 1997b; Friis 2011; Fryer 1990c; Hassan and Grundy 1984; Henn and Bank 1990b; Henn et al. 1994b; Hyrsl and Petrov 1999; Kirk 1955; Koivula and Kammerling 1989b, e; Koivula et al. 1992a; Kondo and Beaton 2009; Liddicoat 1974; Liu 1982, 1991; Naqvi et al. 1991; Paulin 1979; Peterson 1983; Petrov 2009; Pinet et al. 1992; Pizani et al. 1985; Webster 1958; Weerth and Hammer 2000; Wight 1993, 1996; Zilio and Bagnato 1984

Special attention: dye

6.1.77. Sphene (Titanite)

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
FTIR(-NIR) spectroscopy	
Raman spectroscopy	If other tests are inconclusive

References
Aleksandrov and Troneva (2007), Angel et al. (1999), Beirau et al. (2010), Bernau and Franz (1987), Bismayer et al. (1992, 1999), Blasse et al. (1988), Carswell et al. (1996), Cherniak (1993, 1995, 2006, 2010), Cherniak and Watson (2011), Chrosch et al. (1997, 1998), Crowe et al. (1986), Enami et al. (1993), Enkelmann et al. (2005), Farges (1997), Fliegel et al. (2010), Frost et al. (2001), Gaft et al. (2003), Ghose et al. (1991), Green and Pearson (1986), Hawthorne et al. (1991), Hayden et al. (2008), Hayward et al. (2000), Heyns et al. (2000), Holenyi and Annersten (1987), House et al. (2000), Hughes et al. (1997), Kek et al. (1997), Kennedy et al. (2010), Knoche et al. (1998), Kunz et al. (1996, 2000), Liferovich and Mitchell (2005a,b, 2006a,b), Lucassen et al. (2010), Lumpkin et al. (1991), Lussier et al. (2009), Malcherek et al. (1999, 2001), Marks et al. (2008), Mazdab (2009), Meyer et al. (1996, 1998), Morishita et al. (1996), Mukhopadhyay et al. (1992), Oberti et al. (1991), Pan et al. (1993), Paterson and Stephens (1992), Paulmann et al. (2000), Perseil and Smith (1995), Pezzotta (2005), Piuzana et al. (2008), Prowatke and Klemme (2005, 2006), Reiners and Farley (1999), Robinson and Wight (1997), Russell et al. (1994), Salje et al. (1993, 2000, 2011), Seifert (2005), Simonetti et al. (2006), Steiner (2010), Storey et al. (2006), Tanaka et al. (1988), Tiepolo et al. (2002), Tilley and Eggleton (2005), Troitzsch et al. (1999), Tropper and Manning (2008), Vance and Metson (1985), Van Heurck et al. (1991), Vassilikou-Dova and Lehmann (1988), Willigers et al. (2002), Xirouchakis et al. (1997), Xirouchakis and Lindsley (1998), Zhang et al. (1995, 2000, 2002, 2003, 2006)

6.1.78. Spinel

Required Test method	*Remark*
Microscope	
Phenomena	Star, colour change
Refractometer (refractive index)	
Polariscope	
Spectroscope	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
UV-Visible(-NIR) spectroscopy	
Raman/PL spectroscopy	

References
Andreozzi (1999), Andreozzi et al. (2000, 2001), Andreozzi and Princivalle (2002), Arai (1992), Barnes and Roeder (2001), Belykh et al. (2005), Blauwet (2006), Bodinier et al. (1996), Bouchard and Gambardella (2010), Brigida et al. (2007), Bromiley et al. (2010), Carbonin et al. (1996), Chopelas and Hofmeister (1991), Cynn et al. (1992), Czaja (2001), Czaja and Mazurak (1993), Daneu et al. (2007), Dekkers and Woensdregt (2002), Della Giusta et al. (1986), Deren et al. (1996), Dezsi et al. (2000), Finger et al. (1986), Foley et al. (2001), Fregola et al. (2005), Fregola and Scandale (2007), Fregola et al. (2000), Garcia-Lastra et al. (2008), Gobbi et al. (1985), Gritsyna et al. (2004), Hålenius et al. (2010), Harder (1986), Harding and Wall (1987), Harrison et al. (1999), Hlaing (1989), Jouini et al. (2006), Kamenetsky et al. (2001), Kamperman et al. (1996), Kashii et al. (1999), Kumaratilake (1998), King (2004), Krokhin et al. (1998), Kurazhkovskaya et al. (2000), Larsson (1995), Lavina et al. (2002, 2003), Lavrentiev et al. (2003), Lee (1999), Lenaz et al. (2008), Libowitzky (1994), Liermann and Ganguly (2202), Lucchesi and Della Giusta (1994), Lucchesi et al. (1997, 1998), Maekawa et al. (1997), Malsy and Klemm (2010), Martignago et al. (2003), Millard et al. (1992), Muhlmeister et al. (1993), Nakatsuka et al. (2004), Notari and Grobon (2003), Paktunc and Cbri (1995), Palin and Harrison (2007), Princivalle et al. (2006), Righter et al. (2006), Rinaudo and Trossarelli (1997), Rubie and Ross (1994), Sack and Ghiorso (1991), Salviulo et al. (1999), Schmetzer et al. (1989), Shannon and Rossman (1991), Sickafus et al. (1999), Slotznick and Shim (2008), Spry (1987), Strek et al. (1988), Sutherland and Coenraads (1996), Talanov (1986), Taran et al. (2005, 2009), Thy (1995), Uchida et al. (2005), Vilissov et al. (2002), Wang et al. (2006), Warren et al. (2000), Watson and Price (2002), Wdowik et al. (2006), Wyon and Aubert (1986),

Special attention: synthetics, heat-treatment

6.1.79. Spinel (cobalt)

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Chelsea Colour Filter	
Polariscope	
Spectroscope	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
UV-Visible(-NIR) spectroscopy	
LA-ICP-MS Chemistry	

References
Dharmaratne (1993), Fryer (1982, 1986, 1990, 1991), Guo et al. (1994), Ivchinova and Zhelyazkova-Panaitova (1969), Koivula and Fritsch (1994), Koivula and Kammerling (1990), Mitchell (1976), Shannon (1923), Shigley and Stockton (1984)

Special attention: synthetics

6.1.80. Spodumene

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
Long-wave UV fluorescence	
Short-wave UV fluorescence	

References

Anderson and McCarron (2011), Bartkowska et al. (1998), Bobos et al. (2007), Camara et al. (2003), Chandrasekhar and White (1992), Charoy et al. (1992, 2001), Cook (1997), De Lima et al. (2008, 2009), Diego-Gatta et al. (2005), Filip et al. (2006), Gaite et al. (1985), Göd (1989), Gordiyenko et al. (1988), Isotani et al. (2007), Ito and Isotani (1991), Karfunkel et al. (2002), Khomenko and Platonov (1985), Kuznetsova (2009), Kuznetsova and Prokofev (2009), Lagache and Sebastian (1991), Lipatov et al. (2007), London and Burt (1982), Makagon (2009), Mauthner (2011a,b), Natkaniec-Nowak (2007), Nunes and Gomes (1994), Pimeta-Romeiro and Pedrosa-Soares (2005), Pommier et al. (2003), Prencipe et al. (2003), Salis (1995), Singhe and Gilkes (1993), Skogby et al. (1990), Souza et al. (2007, 2009), Tacker (2010), Tribaudino et al. (2003), Walker et al. (1997), Weselucha-Birczynska et al. (2011), Wise (2009), Wise and Anderson (2006), Wood and Williams-Jones (1993)

Special attention: easy cleavage, irradiation: blue-green will fade

6.1.81. Sugilite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
Spectroscope	
Raman spectroscopy	

References
Armbruster and Oberhänsli 1988; Boardman 1964; Chikayama 1981; Clark et al. 1980; de Villiers 1983; Dillon 1981b; Dixon 1985; Dunn et al. 1980; Fritsch and Shigley 1994; Fryer 1981e, 1982e; Henn 1986b; Kammerling and Koivula 1990; Kawachi et al. 1994; Kleyenstuber 1996; Koivula and Fritsch 1995b; Koivula and Kammerling 1990a, 1992a; Moore et al. 2011; Moses et al. 1998b; Murakami et al. 1976; Olivier et al. 1983; Ponalho 1991; Shigley et al. 1987; Taggart et al. 1994; Wilson and Dunn 1978a; Zeitner 1982

6.1.82. Taaffeite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Polariscope	
Raman spectroscopy	

References
Abduriyim et al. 2008; Anderson 1952b, 1967, 1968; Anderson et al. 1951; Anderson et al. 1952; Bank and Henn 1989a; Crowningshield 1974a; Demartin et al. 2004; Demartin et al. 1993; Dillon 1983; Fernando et al. 2005; Fernando and Hofmeister 2000; Fryer 1982f, 1987b, 1988b; Gübelin 1981c; Gunawardene 1984c; Hudson et al. 1967; Jayakody 1983; Johnson and Koivula 1996; Kampf 1991; Kiefert and Schmetzer 1998; Koivula 1986d; Koivula and Kammerling 1991b; Koivula et al. 1992d; Liddicoat 1967a; Moses et al. 1999a; Ponalho 1993; Scarratt 1986c; Schmetzer et al. 1999; Schmetzer et al. 2000; Schmetzer et al. 2006; Schmetzer et al. 2005; Schmetzer et al. 2007; Zoysa 1995

Special attention: Taaffeite is a synonym of Magnesiotaaffeite-2N'2S, Musgravite is a synonym of Magnesiotaaffeite- 6N'3S.

6.1.83. Tektite

Required Test method	*Remark*
Microscope	

Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
FTIR(-NIR) spectroscopy	
Raman spectroscopy	If other tests are inconclusive

References

Albin 1997; Aramu et al. 1994; Artemieva et al. 2002; Baker 1940, 1960, 1961, 1962; Banerjee and Hager 1993; Bentor 1986; Blum and Chamberlain 1992; Bouska 1997; Cohen 1958; de Goutiere 1995; Delano et al. 1986; Delano et al. 1992; Dunlap 1997; Dunlap et al. 1998; Dunlap and Sibley 2004; Faulques et al. 2001; Fenner 1939; Fudali et al. 1987; Futrell 1999a; Futrell 1999b; Ganapathy and Larimer 1984; Giuli et al. 2010; Heide et al. 2001; Jacobs 1997; Kim and Kim 2006; Kinnunen 1990; Koeberl 1990, 1992, 1994; Koivula et al. 1995d; Lee et al. 2004; Neuville et al. 2010; Pinter 1999; Rauch et al. 1992; Reban 1984; Taylor 1962, 1973; Volovetsky et al. 2008; Vrana 1988; Wasson 1991; Zook 1974

6.1.84. Thomsonite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	

References

Almquist 1987; Anderson 1978; Wise 1978

Special attention: characteristic appearance

6.1.85. Topaz

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
Dichroscope	

References

Abbott (1990), Albuquerque et al. (1988), Beny and Periou (1987), Cairncross (2005), Cassedanne (1989), Christiansen et al. (1986), da Costa et al. (2000), Dantas et al. (2006), da Silva et al. (2005), Dewonck et al. (1998), Diego-Gatta et al. (2006), Frazier and Frazier (1990), Frindt et al. (2004), Gabasch et al. (2008), Gaft et al. (2003), Gübelin et al. (1986), Haapala et al. (2007), Hervig et al. (1987), Holzhey (1997), Jackson et al. (2002), Jackson and Valerio (2004), Jones (2006), Komatsu et al. (2003), Krambrock et al. (2007), Leal et al. (2007), Leithner (2008), Leroy et al. (2002), Lyckberg et al. (2009), Marques et al. (2000, 2002), Mizuno et al. (2006), Morteani et al. (2002), Morteani and Voropaev (2007), Nassau (1985), Northrup and Reeder (1994, 1995), Pinheiro et al. (2002), Raines (2001), Rohn (2005), Rojas et al. (2009), Sabioni et al. (2003), Sauer et al. (1996), Schmetzer (1987, 2008), Schott et al. (2003), Shinoda and Aikawa (1994), Song and Yuan (2009), Souza et al. (1995, 2002, 2004, 2006), Spengler (1985), Struth et al. (1999), Taran et al. (2003), Tarashchan et al. (2006), Taylor and Fallick (1997), Watenphul et al. (2010), Watenphul and Wunder (2010), Wise (1995), Wunder et al. (1999), Yukihara et al. (1996, 2002), Yukihara and Okuno (1998)

Special attention: coatings, irradiation and heat treatment

6.1.86. Tourmaline

Required Test method	*Remark*
Microscope	Fracture filling
Phenomena	Cat's-eye, colour change
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
Dichroscope	
Spectroscope	
UV-Visible(-NIR) spectroscopy	
EDXRF chemistry	For Paraiba
Colour call	

References

Abduriyim et al. (2006), Akizuki et al. (2001), Andreozzi et al. (2008), Arif et al. (2010), Aurisicchio et al. (1999), Babinska et al. (2008), Balen and Broska (2011), Benard et al. (1985), Benesch and Wöhrmann (1985), Beurlen et al. (2011), Bilal et al. (1998), Bloodaxe et al. (1999), Bosi (2008, 2010, 2011), Bosi et al. (2004, 2005), Bosi and Lucchesi (2004, 2007), Bueno de Camargo and Isotani (1988), Buettner (2005), Burns et al. (1994), Camara et al. (2002), Cassedanne and Roditi (1996), Castaneda et al. (2000, 2006), Choi and Hawthorne (2002), Clark (2007), Clark et al. (2008), de Oliveira et al. (2002), Dias and Wilson (2000), Dietrich (1985), Dirlam et al. (2002), Ertl (2008), Ertl et al. (2006), Ertl et al. (2003, 2007, 2008, 2010), Federico et al. (1998), Fisher (2011), Fisher et al. (1998), Foit (1989), Foord et al. (1989), Foord et al. (1986), Francis (1985), Fritsch et al. (1990), Furuya (2007), Gasharova et al. (1997), Gonzalez-Carreno et al. (1988), Grice and Ercit (1993), Hawkins et al. (1995), Hawthorne (1996), Hawthorne and Henry (1999), Hawthorne et al. (1993), Henn and Bank (1990), Henry and Dutrow (1990, 1992, 2011), Henry and Guidotti (1985), Henry et al. (2008, 2011), Hughes et al. (2001), Jiang (1998), Jiang and Palmer (1998), Jolliff et al. (1986), Johnson et al. (1997), Jones (2005), Karfunkel and Wegner (1996), Kihara et al. (2007), King (2000), King et al. (1988), Kraczka et al. (1986), Krambrock et al. (2002, 2004, 2009), Laurs et al. (2007, 2008, 2009), London (1986, 2011), Ludwig et al. (2011), Lussier et al. (2008, 2009, 2011), Lussier and Hawthorne (2011), Lyckberg (2011), MacDonald and Hawthorne (1995), Maloney et al. (2008), Marschall et al. (2009), Mashkovtsev et al. (2006), Mattson and Rossman (1987), Milisenda (2005), Milisenda and Henn (2001), Milisenda et al. (2000, 2006), Novak and Povondra (1995), Ottolini and Hawthorne (1999), Peretyazhko et al. (2004), Perugini and Poli (2007), Pesquera et al. (2008), Pieczka (1999, 2000), Pough (1987), Povondra and Novak (1986), Proctor (1985a,b), Reinitz and Rossman (1988), Rosenberg and Foit (1985), Rosenberg et al. (1986), Rossman et al. (1991), Rossman and Mattson (1986), Schmetzer and Bank (1985), Schmetzer et al. (2007), Selway et al. (1998), Setkova et al. (2009, 2010), Shabaga et al. (2010), Shigley et al. (2001), Shtukenberg et al. (2007), Simmons et al. (2001, 2005, 2011), Simonet (2000), Soares et al. (2008), Taran et al. (1993, 1998), Trumbull et al. (2008, 2009), van Hinsberg (2011), van Hinsberg and Marschall (2007), van Hinsberg et al. (2011), Van Hinsberg and Schumacher (2007, 2009), von Goerne and Franz (2000), von Goerne et al. (1999, 2001, 2011), Vorbach (1989), Wilson (1989, 2002, 2007), Zagoroski et al. (1989), Zagorsky (2010), Zagorsky and Peretyazhko (1996), Zolotarev et al. (2007), Zwaan (2015c)

6.1.87. Tugtupite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Long-wave UV fluorescence	
Short-wave UV fluorescence	
PL spectroscopy	

References
Antao et al. 2004; Armstrong and Weller 2006; Chikayama 1981; Danø 1966; Dragsted 1970; Gaft et al. 2009; Jensen and Petersen 1982; Mitchell 1996; Newsome 1976; Petersen 1978; Petersen and Secher 1993; Povarennykh et al. 1971; Sorensen et al. 1971; Tunzi and Pearson 2008; Werner and Plech 1995; Xu and Sherriff 1994

6.1.88. Turquoise

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
FTIR(-NIR) spectroscopy	
EDXRF chemistry	Zachery treatment
Raman spectroscopy	If other tests are inconclusive

References
Crespo-Feo et al. (2010), Dill and Henn (2005), Foord and Taggart (1998), Frazier and Frazier (1999), Fritsch et al. (1999), Frost et al. (2006), Henn and Milisenda (2005), Hull et al. (2008), Jones (2000, 2005), King (2002), Kolitsch and Giester (2000), Mathien (2001), Mirnejad et al. (2010), Pavese et al. (2005), Qi et al. (1998), Reddy et al. (2006), Sharma et al. (1988), Sklavounos et al. (1992), Taki and Hosaka (1988), Taniguchi et al. (2002), Voynick (1999), Yang et al. (2003), Zeitner (1990)

Special attention: impregnation, dye, composites, imitation matrix, synthetics

6.1.89. Ulexite

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	

References
Crowningshield 1957; Garlick and Kamb 1991; Ghose 1978; Sinkankas 1955

Special attention: very soft

6.1.90. Variscite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Spectroscope	
FTIR(-NIR) spectroscopy	
Raman spectroscopy	If other tests are inconclusive

References

Arribas et al. 1970; Barwood 1997; Brown 1990b; Calas et al. 2005; Camprubi et al. 2003; Crowningshield 1960a; Dill et al. 1991; Elton 1996; Garcia-Guinea et al. 2008; Koivula 1986b; Larsen 1942; Liddicoat 1975c; Mertens 1988; Murray 1968; Nickel et al. 2008; Novak 1982; Odriozola et al. 2010; Pepperberg 1911; Pinet et al. 1992; Querre et al. 2008; Schaller 1912; Smith-Gharet 1999; Willing et al. 2008; Wilson 2010; Zeitner 1987

6.1.91. Zircon

Required Test method	*Remark*
Microscope	
Phenomena	Cat's-eye
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Polariscope	
Spectroscope	

References

Akhtar and Waseem (2001), Aines and Rossman (1986), Amelin (2004), Balan et al. (2001), Belousova et al. (1998, 2002), Biagini et al. (1997), Black et al. (2003, 2004), Capitani et al. (2000), Caruba et al. (1985), Chakoumakos et al. (1987, 1991), Chang et al. (2006), Chen et al. (2011), Cherniak et al. (1997), Cherniak and Watson (2003), Claoué-Long et al. (1991), Colombo et al. (1999), Cook (2007), Corfu et al. (2003), Crocombette (1999), Crocombette and Ghaleb (1998, 2001), Ellsworth et al. (1994), Evans et al. (2005), Ewing et al. (1988), Ewing et al. (2003), Farges (1994), Farges and Calas (1991), Farnan and Salje (2001), Faulkner and Shigley (1989), Fedo et al. (2003), Fedotova et al. (2008), Feng et al. (1993), Ferry and Watson (2007), Finch and Hanchar (2003), Finch et al. (2001), Fowler et al (2002), Friis et al. (2010), Gaft et al. (2000, 2002), Gagnevin et al. (2009), Geisler (2002), Geisler et al. (2001, 2002, 2003, 2007), Gerdes and Zeh (2009), Grimes et al. (2007), Halden and Hawthorne (1993), Hanchar et al. (2001), Hanchar and Miller (1993), Hanchar and Rudnick (1995), Hanchar and Watson (2003), Hänni and Weibel (1988), Harley and Kelly (2007), Harley et al. (2007), Hinton and Upton (1991), Hirata and Nesbitt (1995), Hoskin (2000), Hoskin and Ireland (2000), Hoskin and Schaltegger (2003), Iizuka and Hirata (2005), Ireland and Williams (2003), Ireland and Wlotzka (1992), Jackson et al. (2004), Jain et al. (2001), King (2008), Kinny and Meyer (1994), Kolesov et al. (2001), Koschek (1993), Kosler and Sylvester (2003), Lee and Tromp (1995), Makishima and Nakamura (1994), Marks et al. (2008), Mattinson (2005), McLaren et al. (1994), Meldrum et al. (1998, 1999), Menneken et al. (2007), Mezger and Krogstad (1997), Murukami et al. (1986, 1991), Mursic et al. (1992), Nasdala et al. (1995, 1996, 2001, 2005, 2008), Page et al. (2007), Palenik et al. (2003), Payette and Pearson (2011), Pidgeon (1992), Radlinski et al. (2003), Rahn et al. (2004), Reiners (2005), Rignanese et al. (2001), Rimsa et al. (2007), Rios et al. (2000), Rubatto (2002), Rubatto and Hermann (2007), Rupasinghe (1985), Rupasinghe and Senaratne (1986, 1996), Salje et al. (1999), Schärer et al. (2011), Scheepers et al. (1999), Scherer et al. (2007), Simonetti et al. (2005, 2006), Sinha et al. (1992), Siyanbola et al. (2005), Slama et al. (2008), Stern and Amelin (2003), Sturm (1999), Tanner et al. (2004), Tennant et al. (2004), Tiepolo (2003), Tiepolo et al. (2003), Trachenko et al. (2002), Trocellier and Delmas (2001), Valley (2003), Valley et al. (1994, 1998, 2005), Vavra (1990), Wang et al. (1991), Wang and Ewing (1992), Watson and Cherniak (1997), Watson et al. (1997, 2006), Watson and Harrison (2005), Wayne and Sinha (1988), Weber (1990), Weber et al. (1994), Wiedenbeck et al. (2007), Woodhead et al. (2004), Woodhead et al. (1991), Wu and Zheng (2004), Yada et al. (1987), Yuan et al. (2004), Zhang and Salje (2001, 2003), Zhang et al. (2000, 2004)

Special attention: heat treatment

6.1.92. Zoisite

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Dichroscope	
Polariscope	
EDXRF chemistry	Cobalt coating

References
Alemany et al. (2000), Armbruster et al. (2006), Barot and Boehm (1992), Blauer (1996), Comodi and Zanazzi (1997), Czaja et al. (1995), Dörsam et al. (2007), Feineman et al. (2007), Franz and Selverstone (1992), Gottschalk (2004), Grevel et al. (2000), Javier-Ccallata et al. (2011), Jenkins et al. (1985), Koziarska et al. (1994), Langer et al. (2002), Liebscher et al. (2002), Liu et al. (1995), Malisa (2003a,b, 2005), Malisa and Kinabo (2005), McClure and Shen (2008), Muhongo et al. (1999), Notari et al. (2001), Pardieu et al. (2009), Pearson (2008), Poli and Schmidt (1998), Reddy et al. (2011), Schroeder (2010), Smith et al. (1987), Srinivasulu et al. (1992), Wilson et al. (2009), Winkler et al. (1989)

Special attention: heat treatment, clarity enhancement, coating

6.2. Test methods pearls and organic gem materials

6.2.1. Amber

Required Test method	*Remark*
Microscope	Acetone reaction, thermal reaction test
Polariscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
FTIR(-NIR) spectroscopy	

References
Alexandrowicz and Kwiecinska (1977), Anderson (2001, 2006), Anderson and Bray (2006), Anderson and Muntean (2000), Angelini and Bellintani (2005), Azar (2007), Beck et al. (1965), Beck (1982b), Beck et al. (1964), Benson (1961a), Brodzinsky (1985), Brouwer and Brouwer (1980), Brown (1982, 1996a), Brown and Lund (1979), Brown and Snow (1988), Bubshait and Sturman (1993a,b,1996), Cario (1989), Costa (2007), Cox (1953), Crowningshield (1964b, 1977a), Delclos et al. (2007), Dierick et al. (2007), Faibisovich and Bordovskaya (1996), Farrington (1923), Feist et al. (2007), Field (1947), Francis (1988), Fraquet (1982, 1989), Fryer (1983, 1985, 1986, 1987a,b, 1988, 1991, 1993a,b), Grimaldi et al. (1994), Gübelin (1978), Gübelin and Koivula (1986), Helm (1892, 1893, 1894), Hernandez (1980), Hillmer (1999), Hlaing (1999), Hollick (1905), Johnson and Koivula (1997a,b), Kennedy (2002), Koivula and Fritsch (1993a,b,c), Koivula and Kammerling (1992a), Koivula et al. (1992b,c, 1993d, 1995a,b), Kosmowska (1990), Langenheim and Beck (1965), Liddicoat (1970), Liebert (1996), Mills et al. (1984), Mukerjee (1997), Pedersen (2008), Peng and Zhu (2006), Poinar et al. (1999), Poirot (1992), Ragazzi et al. (2003), Rice (1979, 1981b), Safar and Sturman (1998), Scarratt (1986a,b, 1989a,b,c,d), Webster (1951)

Special attention: clarity enhanced, dyed, heated (with pressure), pressed, reconstructed (encased in plastics), faked insects, recent resins

6.2.2. Bone

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	

References
Arnould and Poirot (1975), Brown and Lund (1979), Cognet et al. (2003), Lesh (1980), Mann and Brown (2008), Pewkliang et al. (2008), Scarratt (1992), Webster (1948)

Special attention: dye, impregnation

6.2.3. Copal

Required Test method	*Remark*
Microscope	Acetone reaction, thermal reaction test
Polariscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
FTIR(-NIR) spectroscopy	

References

Clery (2002), Winkler et al. (2001)

6.2.4. Coral

Required Test method	*Remark*
Microscope	Thermal reaction test
Refractometer (refractive index)	If possible
Hydrostatic weighing (specific gravity)	
FTIR(-NIR) spectroscopy	If other tests are inconclusive
Raman spectroscopy	If other tests are inconclusive

References

Akagi et al. 2004; Alamaru et al. 2009; Aliprandi et al. 1983; Allison 1996; Anderson, 2008; Bayer 1996; Beger et al. 2003; Benson 1959; Bocchio et al. 2006; Böhm et al. 2006; Bramanti et al. 2005; Brown 1977, 1978, 1979, 1985; Brown 1996; Brown and Lund 1979; Bubshait and Sturman 1993; Calcinai et al. 2002; Cicogna and Cattaneo-Vietti ,1993; Cohen and McConnaughey 2003; Connell et al. 1997; Crowningshield 1960a, 1975a; de Villiers et al. 1994; Dele-Dubois et al. 1981; Deng et al. 2010; Douglas 2003; Emms 1997; Fritsch and Karampelas 2008a, b; Fryer 1981a, 1984a, 1990a; Gao and Zhang 2002; Gauthier and Karampelas 2009; Greegor et al. 1997; Grigg 1993, 2001, 2004; Grigg and Brown 1991; Grottoli and Eakin 2007; Hakomori and Seto 1951; Henn 2006; Johnson and Koivula 1998a; Karampelas et al. 2009; Kiefert et al. 2000; Koivula and Kammerling 1990a; Leverette et al. 2008; Liddicoat 1974a; Linares et al. (2010); Love et al. 2007; MacFall 1974; Merlin and Dele-Dubois 1986; Nassau 1979a, b; Opresko 1996; Peres and Picard (1964), Pienaar 1981; Roger 1991; Rolandi et al. 2005; Santangelo et al. (1993), Scarratt 1984a, d; Scarratt 1996; Shirai et al. 2008; Sholkovitz and Shen 1995; Sinkankas 1996; Smith et al. 2007; Taki and Hosaka 1988; Torrents et al. 2005; Ugalde et al. 2004; Webster 1954, 1958a, 1973; Wei and Qiu 2004; Weldon 1996

6.2.5. Horn

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Raman spectroscopy	If other tests are inconclusive

References

Brown (1976), Liddicoat (1970), Webster (1973)

Special attention: dye, imitations

6.2.6. Ivory – elephant, mammoth/mastodon, hippopotamus, walrus, narwhal

Required Test method	*Remark*
Microscope	Growth structures
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Long-wave UV fluorescence	
Raman spectroscopy	
X-Ray CT scan	In some cases to view growth structures
References	
Boone (1986), Brown (1978, 1990, 1996), Brown and Lund (1979), Brown and Mann (2007), Brown and Moule (1982), Carra (1970), Crowningshield (1970a,b, 1979), Cuadra (1994), Edwards et al. (1996), Fryer (1981, 1988, 1997), Kunz (1916), Lee (1991), Lesh (1980), Liddicoat (1969a,b), Scarratt (1992), Strack (1975), Webster (1948, 1973)	

Special attention: dye, imitations, CITES issues.

6.2.7. Ivory - vegetable

Required Test method	*Remark*
Microscope	Growth structures
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
References	
Brown (1996), Scarratt (1992), Webster (1949)	

6.2.8. Pearl (*Abalone* Species)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
Raman spectroscopy	
References	
(Aboosally 1998; Anonymous 2000; Bostwick 1938; Brown 1994, 2006; Cropp 1997; Crowningshield 1961a, 1965; Day et al. 2000; Edwards 1913; Fankboner 1991; Fankboner 1995, 2001, 2002; Fryer 1984a, 1993, 1996c, d; Johnson and Koivula 1996a; Kammerling and Fryer 1994; Kelly and Brown 2003; Landman et al. (2001), Li and Zhang 2001; Liu et al. (2002), Luckow 1989; Miyashita and Takagi 2011; Strack (2006), Verma et al. 2006; Wentzell 1998, 2004; Yao et al. 2006; Zaremba et al. 1996	

Special attention: blister versus cyst, damage by acids

6.2.9. Pearl (*Cassis* species)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
Raman spectroscopy	
References	
Landman et al. (2001), Strack (2006)	

Special attention: possible similarity with Melo pearls and other orange porcellaneous pearls, damage by acids, shell imitations

6.2.10. Pearl (*Lobatus gigas*/*Strombus gigas* – Conch)

Required Test method	*Remark*
Microscope	
UV-Visible(-NIR) spectroscopy	
Raman spectroscopy	
References	
Anonymous (1977), Acosta-Salmon and Davis 2007; Davis et al. 1986; Farn (1977, 1979a,b, 1986), Fritsch and Misioroswki (1987), Kamat et al. (2000), Komatsu et al. 1993; Kornitzer (1937), Landman et al. (2001), Mikkelsen (2003), Moses (2001), Sciaguato (2004), Stoner and Ray 1996; Strack (2006)	

Special attention: X-ray discolouration to pink samples, possible similarity to other porcellaneous pearls when not the usual pink colour (i.e., white, orange to purplish), damage by acids, shell imitations

6.2.11. Pearl (*Hyriopsis cummingi* and other freshwater mussels)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	Off-white (stronger than light tones) samples only
EDXRF chemistry	
Raman spectroscopy	
LA-ICP-MS chemistry	If EDXRF is inconclusive
X-Ray CT scan	Difficult cases
References	
Akamatsu et al. (2001), Anonymous (2005a,b), Bai et al. 2012; Farn (1986), Hänni (2000), Howells (2005), Izumida et al. 2011; Jobbins et al. (1993), Karampelas et al. 2007; Landman et al. (2001), Mikkelsen (2003), Scarratt et al. (2000), Sweeny and Latendresse (1982), Strack (2006); Wen et al. 2007; Zhang et al. 2002	

Special attention: natural versus non-beaded cultured, blister versus cyst, bleaching, irradiation, dyes, Maeshori treatment, damage by acids.

6.2.12. Pearl (Imitation)

Required Test method	*Remark*
Microscope	
Microradiography	
Raman spectroscopy	If other tests are inconclusive
References	
Bubshait and Sturman 1996; Farn 1976, 1978, 1979, 1986; Fryer 1984c, d, e, 1986b; Hänni 1996; Johnson and Koivula 1997c, 1999; Kammerling and Fryer 1995a; Kennedy et al. 1988; Koivula et al. 1992a; Mayerson 2001; Poirot 1987; Pough 1965; Scarratt 1984e, 1985b, 1986a, 1992c; Strack (2006), Tan et al. 2005; Webster 1958b, 1966, 1973; Wentzell 2004b	

Special attention: mixed into items with nacreous samples. When applying microradiography, some solid plastic imitations may appear similar to nacreous pearls with a tight structure.

6.2.13. Pearl (*Lambis* species)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
Raman spectroscopy	
References	
Landman et al. (2001), Strack (2006)	

Special attention: possible similarity to other brownish or near-white porcelaneous pearls, damage by acids.

6.2.14. Pearl (*Melo* species)

Required Test method	*Remark*
Microscope	
UV-Visible(-NIR) spectroscopy	
Raman spectroscopy	
References	
Landman et al. (2001), Poppe (1992), Scarratt 1992d, 1994b; Sciaguato 2004; Strack (2006); Traub 1997; Traub et al. 1999	

Special attention: X-ray discolouration to orange samples, possible similarity to other orange porcellaneous pearls, damage by acids, check for shaped examples, shell imitations

6.2.15. Pearl (*Mercenaria mercenaria*)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
Raman spectroscopy	

References
Hill (2004), Landman et al. (2001), Strack (2006)

Special attention: possible similarity to other purplish or even white non-nacreous pearls, damage by acids.

6.2.16. Pearl (*Mytilus* species)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
Raman spectroscopy	

References
Caceres-Martinez and Vasquez-Yeomans 1999; Landman et al. (2001), Narasimhulu and Rao 2000; Strack (2006); Vander Putten et al. 2000; Wentzell and Elen 2004

Special attention: possible similarity to other dark hued or purplish nacreous pearls, damage by acids.

6.2.17. Pearl (*Pinctada fucata*)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	Off-white pearls only
EDXRF chemistry	
Raman spectroscopy	

References
Farn (1986), Hänni (2006), Hurwit (2001), Landman et al. (2001), Mikkelsen (2003), Shirai (1994), Shouguo and Lingyum (2001), Strack (2006), Traub et al. (1999), Walker and Mayerson (2001)

Special attention: possible similarity to other nacreous pearls, blister versus cyst, coatings, irradiated bead nuclei in bead cultured pearls, damage by acids.

6.2.18. Pearl (*Pinctada margaritifera*)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
EDXRF chemistry	
Raman spectroscopy	

References
Ellis and Haws 1999; Farn (1986), Hänni (2006), Hodgkinson 2002; Iwahashi and Akamatsu 1994; Karampelas et al. 2011; Landman et al. (2001), Liu et al. 1999; Mikkelsen (2003), Miyoshi et al. 1987; Pouvreau and Prasil 2001; Rousseau and Rollion-Bard 2012, Sanchez (2004), Shirai (1994), Shouguo and Lingyum (2001), Strack (2006), Wentzel et al. (2000)

Special attention: possible similarity to other nacreous pearls, blister versus cyst, dye, bleaching ("Chocolate pearls"), coatings, damage by acids.

6.2.19. Pearl (*Pinctada maxima*)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	Off-white (stronger than light tones) samples only
EDXRF chemistry	
Raman spectroscopy	
LA-ICP-MS chemistry	If EDXRF is inconclusive
X-Ray CT scan	Difficult cases
References	
Elen (2001, 2002), Ellen and Wentzell (2003), Farn (1986), Hänni (2006), Landman et al. (2001), Mikkelsen (2003), Scarratt (1992, 2001), Scarratt et al. (2012), Shirai (1994), Shouguo and Lingyum (2001), Strack (2006), Traub et al. (1999), Wentzel et al. (2000)	

Special attention: natural versus non-beaded cultured, possible similarity to other nacreous pearls, blister versus cyst, dye, bleaching, coatings, Maeshori treatment, damage by acids.

6.2.20. Pearl (*Pinctada mazatlantica*)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
EDXRF chemistry	
Raman spectroscopy	
References	
Hurwit (2000), Landman et al. (2001), McLaurin (2002), Mikkelsen (2003), McLaurin and Arizmendi (2002), Strack (2006)	

Special attention: possible similarity to other nacreous pearls, blister versus cyst, dye, bleaching ("Chocolate pearls"), coatings, damage by acids.

6.2.21. Pearl (*Pinctada radiata*)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	Off-white (stronger than light tones) samples only
EDXRF chemistry	
Raman spectroscopy	
X-Ray CT scan	Difficult cases

References
Farn (1986), Landman et al. (2001), Mikkelsen (2003), Shirai (1994), Shouguo and Lingyum (2001), Strack (2006), Traub et al. (1999)

Special attention: natural versus non-beaded cultured, possible similarity to other nacreous pearls, blister versus cyst, dye, bleaching, coatings, damage by acids.

6.2.22. Pearl (*Pinna* species [including Atrina species])

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
EDXRF chemistry	
Raman spectroscopy	

References
Landman et al. (2001), Gauthier et al. (1997), Karampelas et al. (2009), Sturman (2014), Strack (2006), Wentzel and Elen (2005)

Special attention: possible similarity to other dark hued nacreous and non-nacreous pearls, durability of heavily cracked samples, damage by acids.

6.2.23. Pearl (*Pleuropoca* species)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
Raman spectroscopy	

References
Landman et al. (2001), Strack (2006)

Special attention: possible similarity to other yellowish to brown porcellaneous pearls, damage by acids

6.2.24. Pearl (*Pteria* species)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
EDXRF chemistry	
PL spectroscopy	Helps with mollusc identification in some cases
Raman spectroscopy	

References

Hurwitt (2003), Landman et al. (2001), Mao et al. (2004), Strack (2006)

Special attention: natural versus non-beaded cultured, a-typical bead nuclei, possible similarity to other nacreous pearls, blister versus cyst, bleaching, dyes, coatings, damage by acids.

6.2.25. Pearl (*Scallop [pectinidae*] species)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
Raman spectroscopy	

References
Federman (2004), Landman et al. (2001), Moragat et al. (2001), Scarratt and Hänni (2004), Strack (2006), Wight (2004)

Special attention: possible similarity to other white to lightly coloured non-nacreous/porcellaneous pearls, damage by acids.

6.2.26. Pearl (*Tridacna* [clam] species)

Required Test method	*Remark*
Microscope	
Microradiography	
UV-Visible(-NIR) spectroscopy	
Raman spectroscopy	

References
Hardy (1947), Landman et al. (2001), Strack (2006)

Special attention: possible similarity to other white to lightly coloured porcellaneous pearls, shell imitations, CITES, damage by acids

6.2.27. Shell

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	

References
Brown 1986, 1988, 1995; Chateigner et al. 2000; Compere and Bates 1973; Dauphin et al. 2008; Dauphin et al. 2005; Day et al. 2000; Farn 1979; Farre et al. 2007; Fitzpatrick and Boyle 2002; Giridhar and Srivatsa 1999; Hainschwang et al. 2010; Hardy 1959; Hedegaard et al. 2006; Hill and Carmihael 2004; Koivula and Kammerling 1989c, d, 1991b; Koivula et al. 1992a; Lee et al. 2008; Li and Zhang 2001; Li 2007; Lin et al. 2006; Liu et al. 2003a; Liu et al. 2002; Liu et al. 2003b; Liu et al. 1999; Markwitz et al. 2003; Mayerson 2001; Narasimhulu and Rao 2000; Parker 1989; Ren et al. 2009; Saucedo et al. 1998; Suzuki et al. 2011; Tagliamonte 1984; Webster (1966), Wye 1991; Yao et al. 2006

Special attention: dye, lustre enhancement

6.2.28. Tortoise shell

Required Test method	*Remark*
Microscope	
Refractometer (refractive index)	
Hydrostatic weighing (specific gravity)	
Short-wave UV phosphorescence	
References	
Brown 1978, 1995b; Brown and Lund 1979; Hainschwang and Leggio 2006; Scarratt 1992a	

Special attention: structure, protein smell (hot point), plastic (common imitation)

6.3. Test methods definitions

6.3.1. Clarity enhancement check/extent

Detection of filling of fissures and/or wide fractures and cavities with oils, resins, or any other filler, and an estimation of the extent of this treatment (e.g., none/ insignificant, minor, moderate, or significant).

6.3.2. Colour call

Precise colour description is required, for instance to make sure a colour-change is present, or to establish whether a sapphire may be called Padparadscha.

6.3.3. Chelsea colour filter

A filter that only transmits deep red and yellow-green light.

6.3.4. DiamondView

The DiamondView instrument illuminates a diamond with intense short-wave ultra-violet radiation and detects the surface fluorescence that is caused. Fluorescence and Phosphorescence images, showing clear growth patterns, are projected on a computer screen.

6.3.5. Dichroscope

An instrument that allows to detect whether a gemstone shows pleochroism and, if it does, to observe the pleochroic colours side by side, for easy comparison and description.

6.3.6. EDXRF chemistry

Energy-dispersive X-ray fluorescence is a technique whereby a sample is targeted by a high-energy X-ray beam, causing its chemical elements to fluoresce with a spectrum of lower-energy X-rays, each peak being characteristic of a chemical element. The relative concentrations of elements are indicated by the fluorescent X-ray peak intensities.

6.3.7. FTIR(-NIR) spectroscopy

Accurate measurement of absorption or transmission positions, and their relative intensities in the (near-)infrared range of the electromagnetic spectrum. The resulting spectra are measured and digitally recorded by a Fourier Transform Infrared spectrometer. “Fourier Transform” is a mathematical technique used to convert the spectrometer signal into a spectrum plotted as a function of energy. The measurements can be done in different modes, such as e.g., transmission, diffusion reflectance, or by using KBr pellets.

6.3.8. Hydrostatic weighing

The method used to measure the specific gravity (SG) of a gemstone. It is based on the principle of Archimedes, comparing the weight of an object in air (A) with the weight of that object in water (W). The SG can then be calculated:

$$SG = A/(A-W).$$

6.3.9. Immersion

A gemstone is immersed in a liquid with a similar refractive index to observe features that are otherwise not or less visible, for instance colour distribution or zoning.

6.3.10. LA-ICP-MS Chemistry

Laser Ablation Inductively Coupled Plasma Mass Spectrometry is an analytical technology that enables highly sensitive elemental and isotopic analysis to be performed directly on solid samples. LA-ICP-MS begins with a laser beam focused on the sample surface to generate fine particles – a process known as Laser Ablation. The ablated particles are then transported to the secondary excitation source of the ICP-MS instrument for digestion and ionisation of the sampled mass. The excited ions in the plasma torch are subsequently introduced to a mass spectrometer detector for both elemental and isotopic analysis. It is not entirely non-destructive, but can perform ultra-highly sensitive chemical analysis down to ppb (parts per billion) level.

6.3.11. Microradiography

The process of taking a photograph of an object by using X-rays, showing minute internal structure.

6.3.12. Microscope

A gemmological microscope is a stereo binocular microscope with good depth of vision and field of view, with generally magnification varying in between 10x and 80x. Research microscopes with much higher magnification power may be used as well in gemmological laboratories.

6.3.13. Phenomena

Detection of phenomena, such as colour-change of a gemstone, when viewed in different light conditions, play of colour, labradorescence, reflection of light by inclusions causing chatoyancy (Cat’s-eye), asterism (Star), aventurescence, adularescence; inclusion patterns causing the trapiche effect, bloodshot effect.

6.3.14. PL spectroscopy

Detection of photoluminescence (light emission) of an object illuminated by a laser. Light emission occurs after the excitation by photons (electromagnetic radiation). Different lasers may be used, for example red (633 nm), green (514 and 532 nm), blue (488 nm) and UV (250 nm) lasers. For diamonds, PL is usually performed at low temperature (-196℃)

6.3.15. Pleochroism

A property of doubly refractive coloured gemstones of absorbing light to an extent that depends on the vibration direction of the polarised light rays. The effect causes two different colours (*dichroism*) or three different colours (*trichroism*), depending on the type of gemstone. These different colours may be seen when viewing a gemstone from different directions under transmitted light.

6.3.16. Polariscope

A polariscope is an instrument with two polarising filters fitted one above the other in a fixed crossed position, meaning that the transmitted vibration direction of polarisation of the upper filter is at right angles to that of the lower filter. The filters are either fixed on an inbuilt light or placed on a separate light source.

6.3.17. Raman spectroscopy

Detection of an extremely slight shift of energy of the light or radiation scattered on the surface of an object illuminated by a laser. The resulting re-emitted spectrum, or Raman spectrum, is characteristic for different (solid or fluid) substances, and allows rapid identification, also if they are enclosed within another transparent substance. Different lasers may be used, for example near-infrared (780 nm), red (633 nm), green (514 and 532 nm), blue (488 nm) and UV (250 nm) lasers.

6.3.18. Refractometer

The gemmological refractometer is designed to measure the refractive index or indices of a gemstone. It makes use of total internal reflection of monochromatic light, going through an in-built special type of glass, which is in contact with a flat, polished surface of a gemstone.

6.3.19. Refractive index

A simple relationship between the light's angle of incidence and angle of refraction (the amount of bending), when it reaches and enters a gemstone. The slower the light's speed in a material, the greater the bending effect, thus the higher the refractive index. Depending on the structure of the material, light will remain as a single ray or be split into two rays; the effects are called "single refraction" (giving one refractive index), and "double refraction" (giving two refractive indices, with a minimum and maximum value).

6.3.20. Residue check/ extent

Detection of residue in healed fissures and/or filled cavities as a result of heat-treatment, and an estimation of the extent of this treatment (e.g., none/ insignificant, minor, moderate, or significant).

6.3.21. Spectroscope

A spectroscope is essentially a tube with a narrow slit at one end and a lens at the other, with in between an arrangement of optically connected prisms, or a diffraction grating, creating a spectrum - spectral colours of white light that enters the slit and are spread out by the prisms or grating and can be viewed through the lens.

6.3.22. Long-wave UV fluorescence

Emission of visible light by a substance when excited by long-wave ultraviolet radiation (principal wavelength of 365 nm), produced by a UV-lamp.

6.3.23. Long-wave UV phosphorescence

Continued emission of visible light by a substance after excited by long-wave ultraviolet radiation (principal wavelength of 365 nm), produced by a UV-lamp.

6.3.24. SEM-EDS

Scanning Electron Microscopy with Energy Dispersive X-Ray microanalysis is a technique, using an electron beam to scan the surface of an object. Scattered electron reflections are detected at very high magnification which are displayed as black-and-white images on a screen. Elemental analysis and mapping can be obtained, as the electrons also cause the object's chemical elements to emit a spectrum of X-rays, each peak being characteristic of a chemical element.

6.3.25. Short-wave UV fluorescence

Emission of visible light by a substance when excited by short-wave ultraviolet radiation (principal wavelength of 254 nm), produced by a UV-lamp.

6.3.26. Short-wave UV phosphorescence

Continued emission of visible light by a substance after excited by long-wave ultraviolet radiation (principal wavelength of 365 nm), produced by a UV-lamp.

6.3.27. Specific Gravity

The ratio of the weight of a substance to the weight of an equal volume of water.

6.3.28. UV-Visible(-NIR) spectroscopy

Accurate measurement of absorption or transmission positions, and their relative intensities in the UV, Visible light (and near-infrared) range of the electromagnetic spectrum. The resulting spectra are measured and digitally recorded by a UV-Visible(-NIR) spectrometer.

6.3.29. X-Ray CT scan

X-Ray computed tomography makes use of computer-processed combinations of many X-ray images taken from different angles around a single axis of rotation, to produces cross-sectional (tomographic) images (virtual “slices”) of specific areas of a scanned object, allowing the user to see inside the object without cutting. Digital geometry processing is used to generate a three-dimensional image of the inside of the object.

6.3.30. XRD

X-Ray Diffraction is a scattering of X-rays by the atoms of a crystal that produces an interference effect so that the diffraction pattern gives information on the structure of the crystal or the identity of a crystalline substance. One of two primary types of XRD analysis (X-ray powder diffraction and single-crystal XRD) is commonly applied.

6.4. Test methods references

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