INTERNATIONAL STANDARD

ISO 7404-1

Third edition
2016-04-01

Methods for the petrographic analysis of coals —

Part 1: Vocabulary

Méthodes d'analyse pétrographique des charbons —

Partie 1: Vocabulaire

Reference number
ISO 7404-1:2016(E)

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Foreword

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The committee responsible for this document is ISO/TC 27, *Solid mineral fuels*, Subcommittee SC 5, *Methods of analysis*.

This third edition cancels and replaces the second edition (ISO 7404-1:1994), which has been technically revised.

ISO 7404 consists of the following parts, under the general title *Methods for the petrographic analysis of coals*:

— *Part 1: Vocabulary*

— *Part 2: Method of preparing coal samples*

— *Part 3: Method of determining maceral group composition*

— *Part 4: Method of determining microlithotype, carbominerite and minerite composition*

— *Part 5: Method of determining microscopically the reflectance of vitrinite*

Introduction

Petrographic analyses have been recognized internationally as important in the context of the genesis, vertical and lateral variation, continuity, metamorphism and usage of coal. The International Committee for Coal and Organic Petrology (ICCP) has made recommendations concerning nomenclature and analytical methods and has described in detail the characteristics of a wide range of coals[3][4][5]. The text of this part of ISO 7404 agrees substantially with the text of the relevant ICCP publications and incorporates many useful comments made by members of the ICCP and by member bodies of ISO/TC 27, *Solid mineral fuels*.

Petrographic analyses of a single coal provide information about the rank, the maceral and microlithotype compositions and the distribution of minerals in the coal. The reflectance of vitrinite is a useful measure of coal rank and the distribution of the reflectance of vitrinite in a coal blend, together with a maceral group analysis, can provide information about important chemical and technological properties of the blend.

ISO 7404 is concerned with the methods of petrographic analysis currently employed in characterizing coal in the context of its technological and/or geological use. It establishes a system for petrographic analysis and comprises five parts, as follows:

— Part 1: Vocabulary;

— Part 2: Method of preparing coal samples;

— Part 3: Method of determining maceral group composition;

— Part 4: Method of determining microlithotype, carbominerite and minerite composition;

— Part 5: Method of determining microscopically the reflectance of vitrinite.

The definitions given are intended for use solely in connection with the generally accepted international methods of petrographic analysis of coal described in the other parts of ISO 7404.

The petrographic terms listed herein are those used by the ICCP and ISO. They do not include terms such as, for example, pseudovitrinite, semi-vitrinite and semi-inertinite which refer to types of maceral with particular properties, but which are sometimes difficult to define. Such terms may be considered important for specific applications, but their wider use is not recommended.

Methods for the petrographic analysis of coals —

Part 1: Vocabulary

1 Scope

This part of ISO 7404 defines terms that are used in connection with both maceral and microlithotype analyses, and with the determination of the reflectance of vitrinite. It applies to the terms used in the examination of coal of all ranks.

This part of ISO 7404 is not intended to be a comprehensive glossary of coal petrographic terminology, nor does it attempt to provide sufficient information to allow recognition of all the coal components described. Further information may be obtained from the relevant ICCP publications[3][4][5].

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1 General terms

2.1.1
coal
combustible sedimentary rock formed from bio- and geochemically altered plant remains (peat) consolidated under superimposed strata

Note 1 to entry: The characteristics of different coals are due to differences in source plant material, in the conditions and the degree of change that the material has undergone in its geological history and in the range of impurities present. Coal composition can be characterized microscopically by maceral and microlithotype compositions.

2.1.2
coalification
process by which sedimented plant remains are transformed into *coal* (2.1.1)

Note 1 to entry: This process is characterized by an increase in the carbon content in the plant remains and a decrease in the yield of volatile matter from the plant remains. As coalification proceeds, the *reflectances* (2.2.1) of the *macerals* (2.3.1) increase. Vitrinite is used as a reference material for the determination of the *rank* (2.1.3) of coal because its reflectance increases uniformly with the extent of coalification.

2.1.3
rank
position of a *coal* (2.1.1) in the *coalification* (2.1.2) series from *low rank coal* (2.1.4) to *high rank coal* (2.1.6), indicating maturity in terms of chemical and physical properties

2.1.4
low rank coal
coals (2.1.1) of low rank that, in their natural state, are characterized by high inherent moisture content, high volatile matter content, low calorific value and a low vitrinite reflectance

Note 1 to entry: Low rank coals were formerly often referred to as lignite (now low rank A and B) and subbituminous coal (now low rank C). Regionally, also terms like brown coal were used for coals with a vitrinite reflectance below 0,5 % R_r.

Note 2 to entry: They are non-agglommerating.

Note 3 to entry: See ISO 11760.

2.1.5
medium rank coal
general descriptive term for *coal* (2.1.1) between *high rank coal* (2.1.6) and *low rank coal* (2.1.4)

Note 1 to entry: The vitrinites in all coals of medium rank melt and form semi-coke when coal is heated in the absence of oxygen above 360 °C to 380 °C. Medium rank coals were formerly referred to as bituminous coals. Their vitrinte reflectance, R_r %, lies between 0,5 % and 2 %.

Note 2 to entry: See ISO 11760.

2.1.6
high rank coal
coal (2.1.1) of high rank, with a low volatile matter content and a semi-metallic lustre, and which does not soften or swell when heated

Note 1 to entry: High rank coals were formerly referred to as anthracites. Their vitrinte reflectance, R_r %, lies between 2 % and 6 %[1].

2.2 Optical microscopy terms

2.2.1
reflectance
percentage of the near-normal incident light reflected from a polished surface of a coal maceral

Note 1 to entry: For the purpose of this part of ISO 7404, reflectance refers to measurements made on coal under oil immersion.

2.2.2
maximum reflectance
highest value of *reflectance* (2.2.1) obtained when any polished section of a particle or lump of *coal* (2.1.1) is rotated in its own plane in linearly polarized light

2.2.3
random reflectance
reflectance (2.2.1) of any polished section of a particle or a lump of *coal* (2.1.1) when determined in non-polarized light without rotation of the specimen

Note 1 to entry: The term “random reflectance” has replaced the old terms “mean reflectance” and “average reflectance” to avoid confusion, mainly with the use of ”mean” for data presenting the mean of the required number of reflectance readings as in, for example, ”mean random reflectance”.

2.2.4
parasitic reflection
percentage of the incident light reaching the measuring device from lens boundary faces and other reflecting surfaces in the microscope

2.2.5
reflectance standard
polished surface of an isotropic material of known *reflectance* (2.2.1) which is used for calibrating reflectance measuring equipment

2.2.6
zero standard
non-reflecting standard used for calibrating reflectance-measuring equipment

2.2.7
particulate block
solid block consisting of particles of crushed *coal* (2.1.1) representative of the sample when prepared accordingly, bound in resin, cast in a mould and with one face ground and polished

Note 1 to entry: See Reference [4].

2.2.8
lump section
piece of *coal* (2.1.1) of size suitable for polishing and examination under the microscope

Note 1 to entry: One face of the lump section, usually that perpendicular to the bedding plane, is ground and polished.

2.2.9
point
area overlain by the intersection of the cross hair in the eyepiece graticule or on the computer monitor during microscopical analysis

2.3 Petrographic terms

2.3.1
maceral
microscopically recognizable organic constituent of *coal* (2.1.1) analogous to the minerals of inorganic rocks, but differing from them in that macerals have no characteristic crystal form and are not constant in chemical composition

Note 1 to entry: The macerals are distinguished from one another microscopically on the basis of their differences in such properties as *reflectance* (2.2.1), colour, fluorescence, morphology, size and hardness. They originate from the remains of different tissues of plants and their physical and chemical properties change as *coalification* (2.1.2) proceeds. Macerals are grouped into maceral groups and sub-groups and can be further differentiated into maceral varieties (see Table 3).

2.3.2
microlithotype
naturally occurring *maceral* (2.3.1) or association of macerals with a minimum layer width of 50 µm

Note 1 to entry: See also 3.2.

2.3.3
minerals in coal
natural inorganic constituents visible during microscopical examination

Note 1 to entry: Minerals are determined on a volume basis as part of a maceral analysis.

2.3.4
mineral matter in coal
inorganic material, except moisture

Note 1 to entry: Mineral matter is calculated on a mass basis either from a direct determination at low temperature or from the ash yield at high temperature.

2.3.5
carbominerite
collective term for intergrowths of minerals and *macerals* (2.3.1)

Note 1 to entry: See also 3.3.

2.3.6
minerite
collective term for intergrowths of minerals with *macerals* (2.3.1) in which the proportion of minerals is more than 60 % by volume, or in which more than 20 % by volume of sulfide minerals is present

3 Classification of macerals, microlithotypes and carbominerites

3.1 Macerals

Three maceral groups are recognized: vitrinite (and its low rank equivalent huminite), liptinite and inertinite. Maceral groups and their sub-divisions are shown in Table 1.

Table 1 — Macerals as defined in the ICCP 1994 System

Maceral group	Maceral sub-group	Maceral		Maceral variety
Vitrinite/ huminite	Telovitrinite/ telohuminite	Telinite	Textinite	
		Collotelinite	Ulminite	
	Detrovitrinite/ detrohuminite	Vitrodetrinite	Attrinite	
		Collodetrinite	Densinite	
	Gelovitrinite/ gelohuminite	Corpogelinite	Corpohuminite	
		Gelinite	Gelinite	
Inertinite	Not sub-groups sensu stricto: (with plant cell structure)	Fusinite Semifusinite Funginite		
	(lacking plant cell structure)	Secretinite Macrinite Micrinite		
	(fragmented inertinite)	Inertodetrinite		
Liptinite		Cutinite Suberinite Sporinite		
		Resinite		
		Exsudatinite Chlorophyllinite		
		Alginite		Telalginite
				Lamalginite
		Liptodetrinite		
		Bituminite		

NOTE 1 Huminite maceral–subgroups can be used synonymously with those from the vitrinite group, huminite macerals, however, cannot be used synonymously with vitrinite macerals.

3.2 Microlithotypes

Microlithotypes are classified in one of three categories, namely monomaceral, bimaceral and trimaceral microlithotypes, according to whether they contain significant proportions of macerals belonging to one, two or three maceral groups. A monomaceral microlithotype contains at least 95 % by volume, on a mineral-free basis, of the principal maceral group. A bimaceral microlithotype contains at least 95 % by volume, on a mineral-free basis, of the two principal maceral groups. A trimaceral microlithotype contains at least 95 % by volume, on a mineral-free basis, of the three principal maceral groups and at least 5 % by volume of each. Microlithotypes may contain not more than 5 % by volume of sulfide minerals or 20 % by volume of clay minerals as impurities.

The classification of the main microlithotypes and their maceral group compositions is given in Table 2.

Table 2 — Classification of the main microlithotypes

Microlithotype	Maceral-group composition (total greater than or equal to 95 % by volume, mineral-free basis)
Monomaceral Vitrite Liptite Inertite	Vitrinite Liptinite Inertinite
Bimaceral Clarite Durite Vitrinertite	Vitrinite + Liptinite Inertinite + Liptinite Vitrinite + Inertinite
Trimaceral Trimacerite	Vitrinite + Liptinite + Inertinite

3.3 Carbominerites

The various types of carbominerite are shown in Table 3.

Table 3 — Types and compositions of carbominerite

Type	Volume percentage of minerals
Carbargilite	20 to 60, clay minerals
Carbopyrite	5 to 20, sulfides
Carbankerite	20 to 60, carbonates
Carbosilicite	20 to 60, quartz
Carbopolyminerite[a]	20 to 60, various minerals
[a] The term is also used for carbopolyminerite containing a minimum of 5 % minerals, provided sulphides form a substantial part of the mineral matter.	

Bibliography

[1] ISO 11760:2005, *Classification of coals*

[2] ICCP. The New Vitrinite Classification (ICCP System 1994) -. Fuel. 1998, **77** pp. 349–358

[3] ICCP. The New Inertinite Classification (ICCP System 1994) -. Fuel. 2001, **80** pp. 459–471

[4] ICCP. (1963, 1971, 1975, 1985, 1993), International Handbook of Coal Petrography

[5] Sykorova I., Pickel W., Christanis K., Wolf M., Taylor G.H., Flores D. (2005) Classification of huminite – ICCP System 1994

ICS 73.040; 01.040.73

Price based on 6 pages