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Title: Descriptive Morphology Terms For MAMA software

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# Descriptive Morphology Terms For MAMA software

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## Abstract:

The table on the following pages lists a set of morphology terms for describing materials. We have organized these terms by categories. Software uses are welcome to suggest other terms that are needed to accurately describe materials. This list is intended as a initial starting point to generating a consensus terminology list.



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| Group | Category | Sub Cate | Term | Definition | Notes |
|---|---|---|---|---|---|
| Primary Shape | General Shape | | Irregular | No one description fits the image correctly. A particle that cannot be described by any one or combination of shapes. Has different measurements in all three directions. | |
| | | | Equiaxed | Having approximately equal dimensions in all directions. Equant, equidimentional. The term is applied to crystals, spheres, sub-spheres, or rounded particles or irregularly shaped particle of any kind in which the particle has approximately equal dimensions in all directions. a symmetrical 3D shape. | NIST, McCrone use Equant. |
| | | | Oblong | Length of outline somewhat greater then width | NIST, McCrone use Oblong. |
| | | | Elongated | Unusually long in relation to its width. A shape referring to a thin or narrow, long structure. Long-thin, lath like (a rectangular elongated shape), rod-like(a rounded cross-section elongated shape) | NIST uses Long-Thin, McCrone uses Lath-like or elongated. ASTM uses Lathe-like |
| | 3D shape X≈Y≈Z | Angular shapes | Quadrangular | Outline has four prominent sides or two parallel sides, most sides straight, one almost right angle. | NIST, McCrone uses Quadrangular, ASTM uses rectangular. Munsell: angular, subangular, blocky |
| | | | Triangular | Outline is roughly triangular or particle has a prominent triangular feature. | NIST, McCrone use triangular. Munsell: angular, subangular, blocky |
| | | | Cuboidal | Outline is roughly cubical in form | Munsell: angular, subangular, blocky |
| | | | Hexagonal | Outline is roughly hexagonal in form. Relating to a crystal system characterized by three equal lateral axes intersecting at angles of 60 degrees, and a vertical axis of variable length at right angles. | Munsell: angular, subangular, blocky |
| | | | Rhomboidal | Outline is roughly a quadrilateral with both pairs of opposite sides parallel and all sides the same length in form. A parallelogram with no right angles. Rhombus and Rhombhedron also used, with slightly different, but overlapping definitions. | Munsell: angular, subangular, blocky |
| | | | Trapezoidal | Outline is roughly trapezoidal in form | Munsell: angular, subangular, blocky |
| | | | Polyhedral | An irregular, but sharply angular shape. Outline is approximately equidimensional, but irregular shaped. Sometimes called Granular | Munsell: angular, subangular, blocky |
| | | Roundish shapes | Spherical | Outline has nearly perfect spherical overall shape. | Sphere used in NIST, McCrone. Spherical/Spherodial in ASTM & ASM |
| | | | Spheroidal | Sub-spherical . Outline has an out-of-perfectly-round, but roughly spherical shape. Globular shape (shaped like a globe.) | Sub-Sphere used in NIST and McCrone. Munsell Soil: Granular & Crumb? |
| | | | Ellipsoidal | Outline is roughly a geometric surface, symmetrical about the three coordinate axes, whose plane sections are ellipses or circles. Ovoid (egg shaped) would generally fall under ellipsoidal | Munsell Soil: Granular & Crumb? |
| | | | Round | most of the overall form looks roundish, but not as uniform as a spheroidal. | Rounded used in NIST, McCrone. Round used because rounded can refer to a process or to edges, rather than a shape. Munsell Soil: Granular & Crumb? |
| | | | Sub-Round | Out of round, but roughly round. A rounded irregular shape. Sometimes nodular or globular | Subrounded used in McCrone, Globular and Nodular used in ASM and ASTM. |
| | 2D shape (X≈Y >> Z) | | Flattened | Oblate (having an equatorial diameter of greater length than the polar diameter), thicker than flake-like and plate-like. i.e. dimension X and Y are larger than dimension Z, but Z not large enough to make the shape quadrangular. A shard is a flattened or plate-like 2D shape with smooth faces and angular or sub angular (sharp) edges. | Note: Plate- like : X&Y >>> Z; Flattened: X&Y > Z, but thicker (z) than flake or plate ; Flake-like: X,Y much larger than z, but in- plane shape is irregular. Flattened used in NIST and McCrone |
| | | | Plate–like | a shape close to 2D. Two dimensions are much larger than the 3rd, but are somewhat similar to each other. Platy has occasionally been used. Lamellar is occasionally used. | Munsell: Platy |
| | | | Flake–like | Very flat shape, close to 2D, but in plane shape is irregular (dimension X and Y are different from each other, but both much larger than Z. Flaky can be a flake-like shape with layers, or an assemblage of flakes | Flake used in NIST, McCrone, Flakes in ASTM, Flaky in ASM. |
| | 1D shapes (X >> Y≈Z) | | Columnar | off-Round cross section that is rigid and relatively slender. used to describe a shape resembling tall, narrow, somewhat cylindrical (but not rounded) or prismatic crystals. | Munsell: Prismatic, Columnar |
| | | | Cylindrical | Columnar with a Round cross section | cylindrical used in NIST, McCrone, |
| | | | Ribbon shaped | Long, thin and relatively flat, can be bent or twisted with irregular edges | Ribbon used in NIST, McCrone. |
| | | | Fiber shaped | In the form of a thread or a structure or object resembling a thread. Thinner than columnar. Can be regular or irregular. Fibrous is often used, but here fiber-shaped is used to describe the overall shape, and fibrous to describe an assemblage. | Fibrous used for agglomerate. Fibrillar used in ASTM |
| | | | Acicular (needles) | Slender pointed objects resembling needles or sharps. | Needles used in McCrone. Acicular in ASM. |
| | | | | | |
| | | | other | None of the shape details below fit the image | Possible Others: Sphenoid/sphenoidal = Wedge-shaped. Ovoid = egg shaped, Tabular= tablet shaped. Shard or Sharps: Like a pottery fragment. Flattened, smooth, broken edges. Roughly uniform thickness. Florets= cauliflower shape; reinform = kidney shaped |
| | | | Straight | Free from curves, bends, angles, or irregularities | |
| | | | Twisted | Appears wrung or twisted by the ends, or along its axis | Twisted used in NIST, McCrone, and ASTM |
| | | | Bent | Overall form is curved or crooked. The bend is sharp and abrupt. | Bent used in NIST & McCrone. |
| | | | Curved | Shape has a turn, change, or deviation from a plane surface without sharp breaks or angularity. A gradual smoother deviation than in a bent shape. Often reaching from end to end. | |

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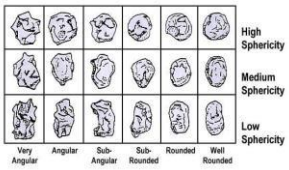
| | | | | |
|---|---|---|---|---|
| **Shapes, Faces, and Edges** | **Shapes & Faces** | **Cone/pointed** | Pointed in a roughly conical fashion or having predominate sharp point - more acute than right angle | Cone/Point used in NIST, McCone |
| | | **Annular** | Having the form of a ring, ring like. | |
| | | **Dendritic** | Having a branched form resembling a tree. Often, having a branched, crystalline shape. | |
| | | **Feathered** | Close to dendritic, but smaller/finer branches. 'softer' looking than dendritic. | |
| | | **Scalloped** | repeating ridges similar to the edge of scallop shell, not necessarily concave. Different than conchoidal. | scalloped used in McCrone |
| | | **Layer** | Any evidence of parallel sheets, stacked sheets, layers or cleavage (splitting along definite crystallographic planes), not crust or scale or other surface feature. Flaky is a flake-like shape with layers | NIST uses Layers, McCrone uses Layers and Cleavage and foliated. ASTM uses flakes, stacked sheets. ASM uses Flaky. |
| | | **Concave** | Dish-like or with prominent pit or hollow; having a collapsed/ indented face. | |
| | | **Twinned** | That is a composite consisting of two or more parts that are reversed within a planar boundary in crystallographic orientation with respect to each other | |
| | **Edges** | **Angular** | Also known as Euhedral. Sharp edges, roughly polyhedral or angulated;Sharp edges, prominent, slightly rounded or straight or piecewise crooked, but not wiggly | Euhedral & Angular both used in NIST, McCrone. Irregular sometimes used. |
| | | **Sub-angular** | Also known as subhedral. Somewhat rounded straight edges rather than sharp edges. Free from sharp edges, but not smoothly rounded. | Subhedral and subangular used in NIST, McCrone. |
| | | **sub rounded** | partially rounded. | |
| | | **Rounded** | Edges are more rounded, edges and corners smoothed to broad curves. Still could be a regular polyhedral shape, but edges of shape are not sharp. | |
| | | ***Others (?)*** |  Chart taken from http://www.agcsa.com.au/static/atm_articles/html/2_4f.html | This set could be expanded to include the "Very" and "Well" categories. |
| | | | | |
| **Surface Features** | **General Texture** | **Smooth** | Looks smooth and even 'glass like' surface. | used by NIST, McCrone, ASTM. |
| | | **Somewhat-Smooth** | Somewhat looks smooth and even 'glass like' surface. | NIST and McCrone use Sub-Smooth |
| | | **Somewhat-Rough** | Somewhat looks to having a broken, uneven, or bumpy surface | NIST and McCrone use Sub-rough |
| | | **Rough** | Looks to having a broken, uneven, or bumpy surface, grainy surface | used by NIST, McCrone, ASTM. ASTM also uses roughened. |
| | **Décor-ations** | **Decorated** | Significant individual particles or other material on surface | used by NIST, McCrone. |
| | | **Crust** | Thick rough broken or discontinuous layer on surface | used by NIST, McCrone. |
| | | **Scale** | Thin, broken or discontinuous layer on surface | used by NIST, McCrone. |
| | | **Fibers** | In the form of a thread or a structure or object resembling a thread on the surface | |
| | | **other** | | Could add Needles or Shaprs or Shards (used by McCrone, NIST, ASTM respectively.) |
| | **Additional Texture Terms** | **Friable** | Look to be easily broken up or crumbly. Friable is more of a condition than a morphology. To determine friable from an image, there should be lots of small detritus around the friable particle. Duplicate in particle distribution. | |
| | | **Smoothed** | Looks smooth as if by melting or by covering in glue or other layer. Melted appearance. | |
| | | **Lumpy** | Prominent protruding rounded bumps. Surface appears to be Globular clusters | NIST distinguishes Grape-like (uniform closely spaced rounded bumps) from lumpy. |
| | | **Fibrous** | Consisting of, containing, or resembling a bundle of fibers. Appears like an aggregate of fibers, but not necessarily an actual aggregate, and not necessary a long thin object. | |
| | | **crystalline** | crystalline grain boundaries, Can appear as cracks. | NIST uses. |
| | **Surface Markings** | **Rippled** | Small or shallow, roughly parallel waves or folds. less distinct than layers. Unlike striations, which are more like scratches. Less distinct layers can appear rippled. | NIST and McCrone use Ripples |
| | | **Striated** | Parallel closely spaces scratches or channel. Sometimes looks like layers seen edge on. Striations can be more apparent in the backscatter image than in the secondary image | NIST/McCone use |
| | | **Channeled** | Relatively rounded grooves of any size, not necessarily oriented. Sintered particles can look like they have channels. | |
| | | **Conchoidal** | Having smooth shell-shaped convex and concave surfaces. curved breakage surface that resembles the rippling, gradual curves of a mussel shell, i.e. conchoidal fracture, with radiation of lines/ridges from a single point, like a fan or a seashell. Glass shards are smooth surface, with angular edges and conchoidal fractures. | |
| | | **other** | | |
| | **Porosity** | **Holes** | A few prominent deep pits (big holes) | Possibly need to add Shallow/Deep to option to pitted/holes. |
| | | **Pitted** | Significant number of deep pits-lots of holes and indentations | NIST and McCrone use |
| | | **Porous** | Appears to be permeable to water, air, or other fluids. Very large number of smaller/variable size holes. | NIST and McCrone and ASTM use |
| | | **Sponge-like** | Resembling wood moss, particles close together in clumps or mats. Really Porous, honeycombed. More hole volume than material. | honeycombed used in McCrone; Spongy in ASTM |

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| | | | | |
|---|---|---|---|---|
| **Particle Distribution** | | **Bimodal** | two generally distinct particle shapes or sizes. Other Multi-modal should be listed as mixture | |
| | | **Variable** | The particle distribution is not uniform throughout the image. A broad range of size and shapes. Also called polydisperse | |
| | | **Mixture** | The simultaneous presence of multiple size/shape groups of particles, but not so variable as to be polydisperse. | |
| | | **Monodisperse** | Particles that are mono-sized and similar shaped. | |
| | | **Fines** | The portion of a powder composed of particles which are smaller than the majority of particles or material | |
| | | **Friable** | Look to be easily broken up or crumbly. Friable is more of a condition than a morphology. To determine friable from an image, there should be lots of small detritus around the friable particle | |
| | | **other** | | |
| | | | | |
| **Particle Masses ar** | **Assembl** | **Conglomerate** | A particle consisting of many dissimilar particles--HETEROGENEOUS MASS | Used in NIST and McCrone |
| | | **Agglomerate** | A jumbled mass of similar particles held together A mostly HOMOGENEOUS MASS. Aggregate and agglomerate are often used to describe the type of interaction (strong/weak chemical bonding or attachment); however they are frequently interchanged in various glossaries and standards. Only agglomerate is used here, following recommendations in the open literature. Sintered, smooth, fractured, or friable can be added to describe the strength or weakness to which the particles appear to be held together. | aggregate used in NIST, both aggregate and agglomerate used in McCrone. |
| | | *Highly Agglomerated* | tending toward a mass in which breaks between clumps/particle are hard to distinguish--cannot distinguish if it is surface texture on a larger particle, or a agglomerate all the way through | not yet added |
| | | *Weakly agglomerated* | some agglomerate, some free-ish looking particles --a mass in which particle or sub particles seem to be apparent, but delineating individual particles or sub-agglomerates would still require subjective judgment | not yet added. |
| | **description of the assemblage** | **Sintered** | Appears to be formed by a coherent mass by heating without melting. | |
| | | **Friable** | | |
| | | **Globular** | An assemblage that consists of small globes or rounded particles. | clumped (ASTM term)? |
| | | **Granular** | An assemblage that appears to consist of small grain-like particles | clumped (ASTM term)? |
| | | **quadrangular** | (May be same as granular?) | |
| | | **Plate-like/Laminar** | An assemblage that appears to consist of plate like particles. | |
| | | **Acicular** | An assemblage that appears to consist of slender pointed objects resembling needles or sharps or fine pointy shards. | |
| | | **Fibrous** | An assemblage that has the appearance of a group of threads or fibers | Fibers used to describe shape of particle, Fibrous to describe agglomeration. |
| | | **Flaky** | An assemblage that consists of flakes or layers | |
| | | **heterogeneous** | An assemblage that consists of subparticles of different structures | |
| | | **Columnar** | an assemblage that consists of particles with off-rounded cross section that is rigid and relatively slender. An assemblage of tall, narrow, somewhat cylindrical (but not rounded) or prismatic crystals. | |
| | | **other** | | |
| | | | | |
| **Inferred Processing** | | **Sintered** | Particles that have formed a coherent mass by heating without complete melting; Particles that have bonded into a mass by partial fusion. | Possibly add Smoothed, as if melted, covered by layer. But hard to distinguish? |
| | | **Cracked** | Prominent breaks in objects or surface. Not simply cracks between crystallographic planes or grain boundaries. Not layers. | *note: These are degrees of the same thing: Cracked = started to crack, Crushed = a lot of cracks , and fragmented = totally crushed to fragments . Not cracks between crystallographic planes/grain boundaries, not layers. NIST/McCrone use Cracks.* |
| | | **Crushed** | Heavily creaked and flattened, appears to have been crushed as in a mortar and pestle, or squeezed enough to cause many cracks or substantial breaking. (crushed is cracked/broken to a greater degree than cracked.) | NIST, McCrone use Crushed. |
| | | **Fragmented** | Two or more prominent separate pieces. Totally cracked/crushed broken to a greater degree than crushed or cracked. | Nit uses fragmented |
| | | **Scratched** | Random oriented individual groove. Etched. | NIST, McCrone use scratched. |
| | | **Dissolved** | Looks partially dissolved or melted away, like a partially melted piece of ice. | Possibly add Smoothed, as if melted, covered by layer. But hard to distinguish? |
| | | **Deposited** | The appearance of matter laid down gradually as a layer or covering. As if agglomerated by deposition from suspension. | NIST, McCrone use deposited. |

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# Terms not currently included in the software, and not specific to morphology, but often added to shape descriptions

| | | | | |
|---|---|---|---|---|
| Image Quality Description | OVERAL L Quality | Best/ Good<br>Average/ Normal<br>Bad/ poor | Should eventually make quantitative or semi-quantitative, like fingerprint and satellite image assessment. Will likely be needed for assigning uncertainties. | (these should be separate category from morphology, but should be added since image quantify and artifacts are critical for comparing images.) |
| | artifacts & effects | obscured | | |
| | | blobs Bright | Uniform in appearance except for bright or dark blobs, reflecting variability in composition rather than topography. See also uniform and bright-spots. 1 | |
| | | spots blurry | | |
| | | uniform | See also obscured, volume. Primarily for backscatter images, but also applicable to particularly blurry secondary images | |
| | | pixelated | Primarily for secondary images. Uniform as opposed to blobs and bright spots, which seem to indicate variation in composition | |
| | | Clear/Crisp | | |
| | | other artifacts | Crisp detail, applicable to secondary images or other imaging modes that normally look blurry. Often Sharp is used here, which has other meaning. | |
| | | charging | | |
| | | surface | | |
| | | vibrations | Surface like rather than volume like. Applicable to backscatter images and other imaging modes that might not normally look this way. See VOLUME. | |
| | | very fine | <1mm in diameter | |
| Munsell Soil terms | | fine | 1-2 mm in diameter | (Note, not included in software since scale not part of most SEM or microscopy images, but should be part of bulk material morphology |
| | | medium | 2-5 mm diameter | |
| | | coarse | 5-10 mm diameter | |
| | | very coarse | > 10 mm diameter | |
| | | opaque/ | | |
| Color Terms | | | Many options here--Color is universally hard to assign. Munsell soil color can be used for bulk | |
| | | Color | materials and have the advantage of being a color space that was based on how people perceive colors (It is a perceptually uniform color space). Also has existing standards cards to use & developed methodologies for using them correctly. There are conversions apps/programs/code bits available to convert Munsell to RGB or CMYK color spaces (better suited for monitor display or printing), but monitors (and printers) are seldom calibrated to display consistent colors ("The color on your screen may not reflect the actual color..."). Therefore, we have removed color as digital image attribute, but can add color (in Munsell or converted Munsell) as metadata. | **Thanks Marianne Wilkerson & Alison Tamasi for introducing us to Munsell color terms!** |
| | | none | | |
| Inclusions | | foreign | | Needs to be refined/improved. |
| | | bubbles | | |
| | | acicular crystals | | |
| | | amorphous mass | | |
| | | nitride | | |
| | | carbide | | |
| | | regular crystal | | |
| | | High/low contrast | | |
| Imaging techniques | | High/low resolution | (optical microscopy and SEM categories- currently unorganized and incomplete.) | (will be incorporated into meta data |
| | | false color | | |
| | | transmitted light | | |
| | | reflected light | | |
| | | backscatter electron | | |
| | | image secondary electron | | |
| | | image hexagonal | | |
| Crystallo-graphic terms | | cubic | | No plans to add yet |
| | | triclinic | | |
| | | tetragonal | | |
| | | orthorhombic | | |
| | | monoclinic | | |
| | | prismoidal | (plus others) | |
| | | anisotropic/ isotropic | | |
| | | | | |

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