

Wollastonite – characterization of needle-shaped crystals with static image analysis

Instrument: CAMSIZER M1

The Mineral Wollastonite

Wollastonite (CaSiO_3) is a colorless chain silicate which occurs in metamorphic rocks and forms when an impure limestone is subjected to temperatures $> 600^\circ\text{C}$. Due to its high melting point at 1540°C , wollastonite is a suitable raw material for the production of refractory materials, ceramics, insulators, fire-resistant clothing; but it is also used as filler medium in paints, plastics, or friction pads.

Two wollastonite samples have been analyzed with the CAMSIZER M1 static image analyzer to determine the size and shape distribution. The mineral usually forms acicular crystals. The analysis of both width and length is therefore required to thoroughly characterize the material.



Fig. 1: Milled wollastonite sample for analysis (left) and rock specimen with white crystals of wollastonite (right, source: Wikipedia).

Static Image Analysis with the CAMSIZER M1

The CAMSIZER M1 uses the principle of static image analysis (ISO 13322-1) to determine the particle size and particle shape in a measuring range from $0.5\ \mu\text{m}$ to $1500\ \mu\text{m}$. An object slide with sample material is shifted stepwise along a camera system which acquires one image per step. The samples may be dry or wet (powders or suspensions). In contrast to dynamic image analysis, the sample remains stationary during the image acquisition. Hence, the particle images show excellent quality and richness of detail. The CAMSIZER M1 particle size / particle shape analyzer features a powerful illumination unit, a highly precise sample stage and five objectives with magnifications from 2.5x to 50x. Thanks to the wide traversing range of the sample stage, an area corresponding to up to eight standard object slides can be evaluated. The CAMSIZER M1 uses an 18.1 Megapixel color camera for image acquisition which guarantees rapid and accurate particle analysis over the entire measuring range.

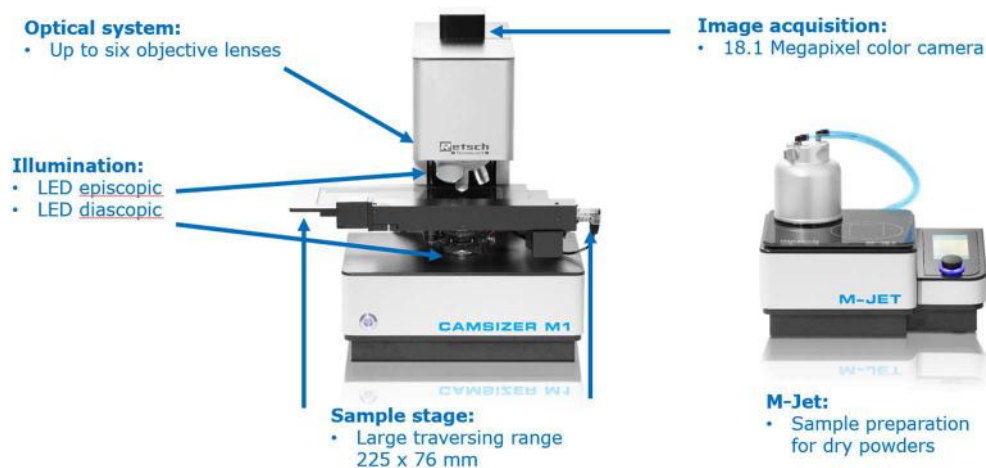


Fig. 2: CAMSIZER M1 is a powerful static image analyser. For sample preparation of dry powders, the M-Jet module is available

Sample Preparation

Two powder-like wollastonite samples were analyzed with the CAMSIZER M1. Prior to the measurement, the samples were dispersed on a 76 x 52 mm microscope slide using the M-Jet dry dispersion module. A glass slide is placed under the dispersion chamber of the M-Jet which is subsequently evacuated. As the chamber is flushed with ambient air, the powder from the sample holder is carried into the chamber and is homogeneously distributed onto the glass slide.

The samples were measured with the CAMSIZER M1 with the size definitions $x_{c\ min}$ (particle width), and $x_{Fe\ max}$ (particle length), the particle shape is detected simultaneously. The instrument was set up for transmitted light and 5 x magnification. Sample 2 was additionally measured with 10 x magnification. An area of 25 x 35 frames was scanned with 5 x magnification and 40 x 50 frames with 10 x magnification. Up to 70 000 particles were analyzed in this way. Analysis time was approx. 5 minutes at 5 x magnification and 12 minutes at 10 x magnification.

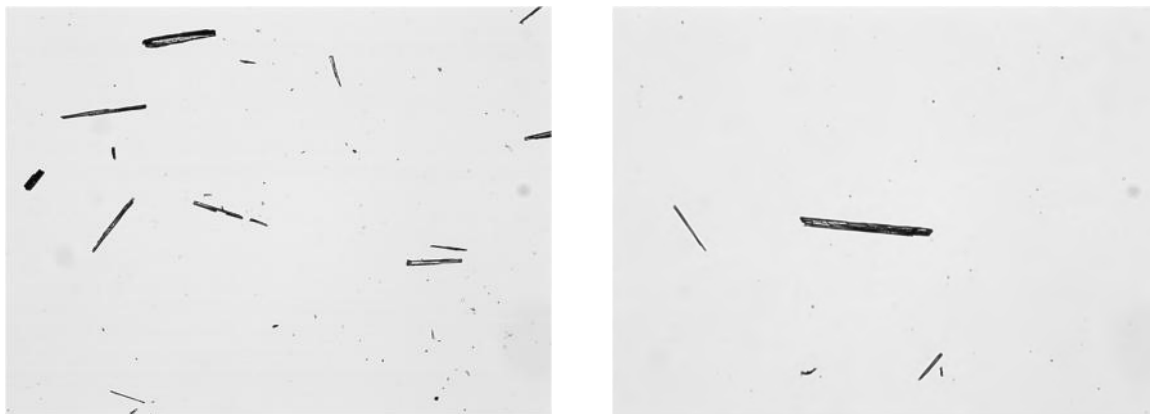


Fig. 3: Example images of the wollastonite samples taken by the CAMSIZER M1 powders. Left: sample 1, 5 x magnification, right: sample 2, 5 x magnification. The acicular geometry of the particles is evident.



Fig. 4: Wollastonite sample 1, overview image of the measurement area, 10 x magnification, transmitted light

Fig. 3 shows digital images taken of sample 1 and 2 by the CAMSIZER M1. Every image is evaluated in real time and saved for subsequent analysis. An overview image is created which gives the user the opportunity to evaluate dispersion quality and check for contamination (Fig. 4).

Results

In the following diagrams the size distribution is expressed by:

- Cumulative distribution Q_3

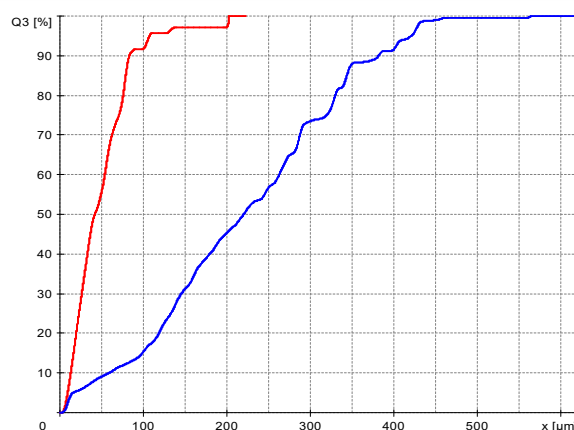


Fig. 5: Size graphs of Wollastonite Sample 2. Size definition **particle width** ($x_{c \min}$, **red**) and **particle length** ($x_{Fe \max}$, **blue**). CAMSIZER M1, transmitted light, 5 x magnification.

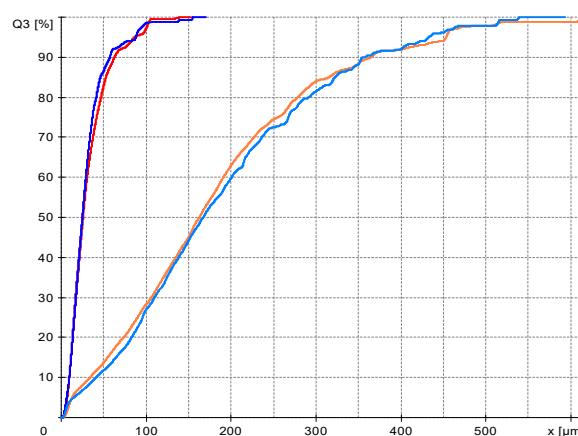


Fig. 6: Size graphs of Wollastonite Sample 1. Size definition **particle width** $x_{c \min}$ **5 x magnification** (**red**) and **10 x magnification** (**blue**) – **particle length** ($x_{Fe \max}$) **5 x magnification** (**orange**) and **10 x magnification** (**light blue**) CAMSIZER M1, transmitted light. The results are almost identical, but the measurement with 5x magnification is significantly faster.

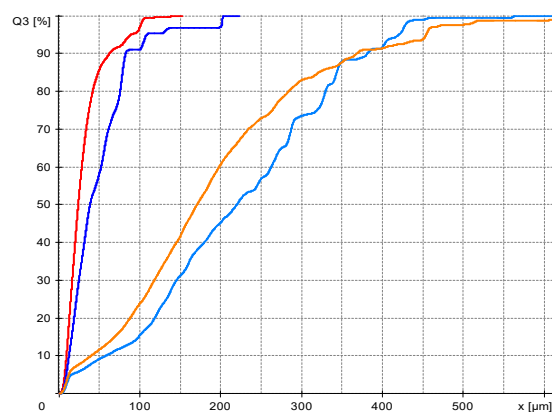


Fig. 7: Size graphs of Sample 1, $x_{c \min}$ (**red**) Sample 2 $x_{Fe \max}$ (**orange**), Sample 2 $x_{c \min}$ (**blue**) and Sample 2 $x_{Fe \max}$ (**light blue**) 5 x magnification.

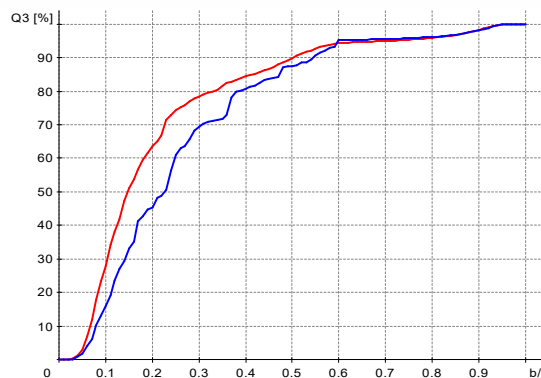


Fig. 8: Shape graphs of Wollastonite sample 1 (red) and wollastonite sample 2 (blue), shape parameter **aspect ratio** (b/l), 5 x magnification, transmitted light. Sample 1 has a lower aspect ratio than sample 2.

Particle Evaluation

All images that are acquired during the measurement are saved and can be used for later evaluation. The Particle X-Plorer software offers many possibilities to evaluate images or individual particles. Filter options are available to browse for particles with selected characteristics. In the following, the 30 longest particles from each sample are listed. Note that all relevant size and shape data are displayed right next to the particle images.

 Cam:0 Img:396 Part:1 Conv 0,9834 XcMin 0,0268 mm XFeMax 0,1734 mm ImageNo 396,0000 XMaMin 0,0259 mm XInner 0,0259 mm XArea 0,0686 mm Aspect Ratio 0,1543 Roundness 0,4592 Symmetry 0,8941 Transparency 0,0699 Compactness 0,3958 Circularity 0,5883	 Cam:0 Img:603 Part:2 Conv 0,9621 XcMin 0,0111 mm XFeMax 0,1770 mm ImageNo 603,0000 XMaMin 0,0096 mm XInner 0,0104 mm XArea 0,0460 mm Aspect Ratio 0,0625 Roundness 0,7473 Symmetry 0,9323 Transparency 0,1945 Compactness 0,2596 Circularity 0,4005	 Cam:0 Img:316 Part:1 Conv 0,9254 XcMin 0,0115 mm XFeMax 0,1765 mm ImageNo 316,0000 XMaMin 0,0088 mm XInner 0,0107 mm XArea 0,0452 mm Aspect Ratio 0,0650 Roundness 0,9054 Symmetry 0,8210 Transparency 0,2604 Compactness 0,2563 Circularity 0,3829
 Cam:0 Img:690 Part:2 Conv 0,9615 XcMin 0,0125 mm XFeMax 0,1851 mm ImageNo 690,0000 XMaMin 0,0117 mm XInner 0,0119 mm XArea 0,0487 mm Aspect Ratio 0,0674 Roundness 0,3673 Symmetry 0,8462 Transparency 0,2234 Compactness 0,2631 Circularity 0,4119	 Cam:0 Img:260 Part:1 Conv 0,9769 XcMin 0,0314 mm XFeMax 0,1947 mm ImageNo 260,0000 XMaMin 0,0312 mm XInner 0,0307 mm XArea 0,0789 mm Aspect Ratio 0,1613 Roundness 0,2886 Symmetry 0,8751 Transparency 0,1620 Compactness 0,4053 Circularity 0,5802	 Cam:0 Img:97 Part:25 Conv 0,9392 XcMin 0,0320 mm XFeMax 0,2011 mm ImageNo 97,0000 XMaMin 0,0264 mm XInner 0,0297 mm XArea 0,0820 mm Aspect Ratio 0,1591 Roundness 0,1822 Symmetry 0,8204 Transparency 0,0383 Compactness 0,4077 Circularity 0,5870
 Cam:0 Img:534 Part:7 Conv 0,9477 XcMin 0,0196 mm XFeMax 0,2042 mm ImageNo 534,0000 XMaMin 0,0195 mm XInner 0,0188 mm XArea 0,0605 mm Aspect Ratio 0,0961 Roundness 0,0000 Symmetry 0,8560 Transparency 0,1525 Compactness 0,2961 Circularity 0,4566	 Cam:0 Img:177 Part:1 Conv 0,9554 XcMin 0,0158 mm XFeMax 0,2179 mm ImageNo 177,0000 XMaMin 0,0140 mm XInner 0,0150 mm XArea 0,0602 mm Aspect Ratio 0,0723 Roundness 0,6163 Symmetry 0,8701 Transparency 0,2311 Compactness 0,2765 Circularity 0,4141	 Cam:0 Img:273 Part:1 Conv 0,9020 XcMin 0,0150 mm XFeMax 0,2159 mm ImageNo 273,0000 XMaMin 0,0143 mm XInner 0,0142 mm XArea 0,0558 mm Aspect Ratio 0,0695 Roundness 0,0000 Symmetry 0,8135 Transparency 0,4136 Compactness 0,2585 Circularity 0,3674
 Cam:0 Img:4 Part:11 Conv 0,9433 XcMin 0,0117 mm XFeMax 0,2135 mm ImageNo 4,0000 XMaMin 0,0090 mm XInner 0,0109 mm XArea 0,0490 mm Aspect Ratio 0,0546 Roundness 0,5089 Symmetry 0,8720 Transparency 0,1295 Compactness 0,2294 Circularity 0,3461	 Cam:0 Img:290 Part:15 Conv 0,9188 XcMin 0,0127 mm XFeMax 0,2130 mm ImageNo 290,0000 XMaMin 0,0099 mm XInner 0,0117 mm XArea 0,0503 mm Aspect Ratio 0,0595 Roundness 0,0586 Symmetry 0,8874 Transparency 0,0900 Compactness 0,2360 Circularity 0,3560	 Cam:0 Img:285 Part:7 Conv 0,9508 XcMin 0,0085 mm XFeMax 0,2218 mm ImageNo 285,0000 XMaMin 0,0084 mm XInner 0,0077 mm XArea 0,0442 mm Aspect Ratio 0,0383 Roundness 0,6394 Symmetry 0,9137 Transparency 0,2446 Compactness 0,1990 Circularity 0,3112

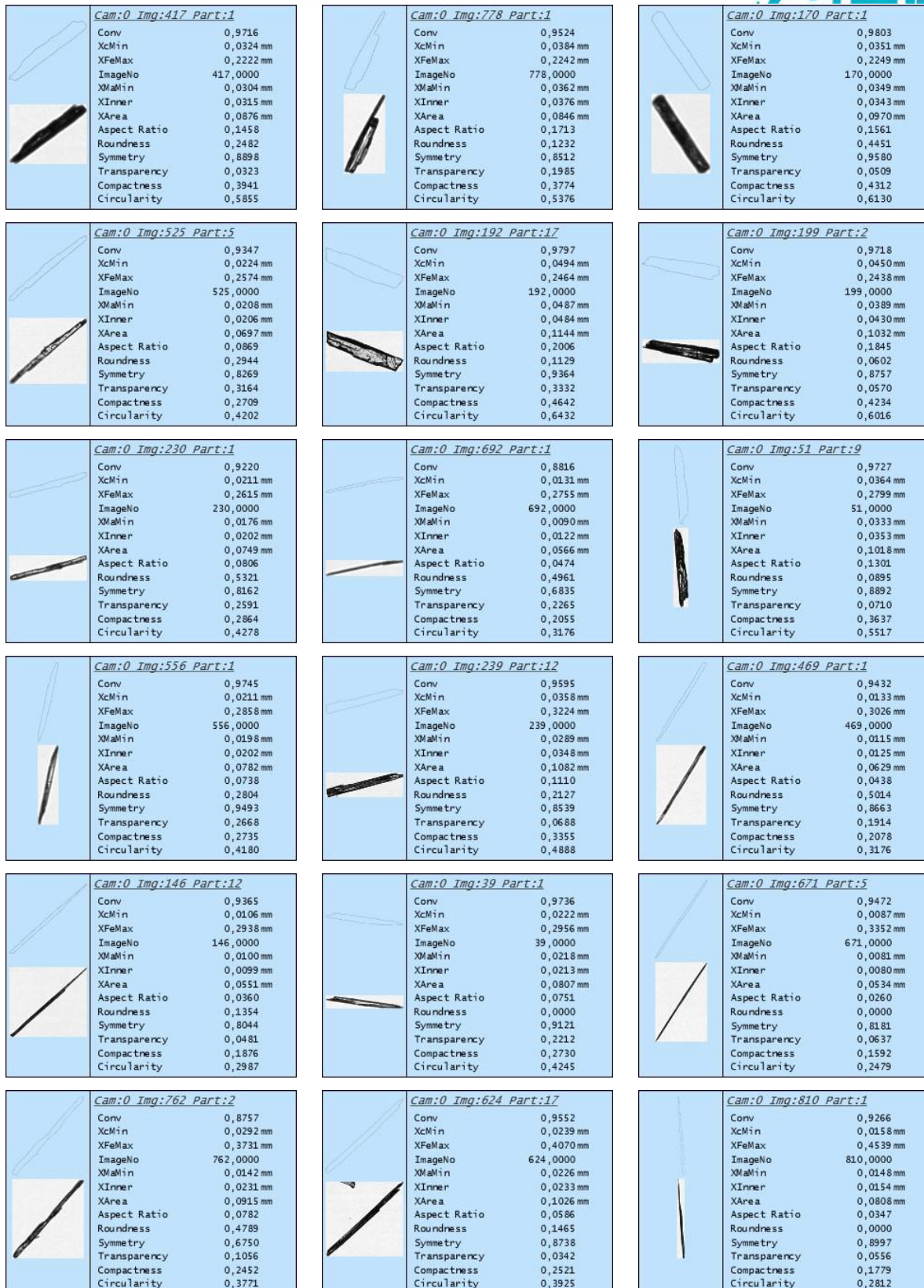


Fig. 9: The 30 longest particles of sample 1



Cam:0 Img:396 Part:1

Conv	0,9834
XcMin	0,0268 mm
XFeMax	0,1734 mm
ImageNo	396,0000
XMaMin	0,0259 mm
XInner	0,0259 mm
XArea	0,0686 mm
Aspect Ratio	0,1543
Roundness	0,4592
Symmetry	0,8941
Transparency	0,0699
Compactness	0,3958
Circularity	0,5883



Cam:0 Img:603 Part:2

Conv	0,9621
XcMin	0,0111 mm
XFeMax	0,1770 mm
ImageNo	603,0000
XMaMin	0,0096 mm
XInner	0,0104 mm
XArea	0,0460 mm
Aspect Ratio	0,0625
Roundness	0,7473
Symmetry	0,9323
Transparency	0,1945
Compactness	0,2596
Circularity	0,4005



Cam:0 Img:316 Part:1

Conv	0,9254
XcMin	0,0115 mm
XFeMax	0,1765 mm
ImageNo	316,0000
XMaMin	0,0088 mm
XInner	0,0107 mm
XArea	0,0452 mm
Aspect Ratio	0,0650
Roundness	0,9054
Symmetry	0,8210
Transparency	0,2604
Compactness	0,2563
Circularity	0,3829



Cam:0 Img:690 Part:2

Conv	0,9615
XcMin	0,0125 mm
XFeMax	0,1851 mm
ImageNo	690,0000
XMaMin	0,0117 mm
XInner	0,0119 mm
XArea	0,0487 mm
Aspect Ratio	0,0674
Roundness	0,3673
Symmetry	0,8462
Transparency	0,2234
Compactness	0,2631
Circularity	0,4119



Cam:0 Img:260 Part:1

Conv	0,9769
XcMin	0,0314 mm
XFeMax	0,1947 mm
ImageNo	260,0000
XMaMin	0,0312 mm
XInner	0,0307 mm
XArea	0,0789 mm
Aspect Ratio	0,1613
Roundness	0,2886
Symmetry	0,8751
Transparency	0,1620
Compactness	0,4053
Circularity	0,5802



Cam:0 Img:97 Part:25

Conv	0,9392
XcMin	0,0320 mm
XFeMax	0,2011 mm
ImageNo	97,0000
XMaMin	0,0264 mm
XInner	0,0297 mm
XArea	0,0820 mm
Aspect Ratio	0,1591
Roundness	0,1822
Symmetry	0,8204
Transparency	0,0383
Compactness	0,4077
Circularity	0,5870



Cam:0 Img:534 Part:7

Conv	0,9477
XcMin	0,0196 mm
XFeMax	0,2042 mm
ImageNo	534,0000
XMaMin	0,0195 mm
XInner	0,0188 mm
XArea	0,0605 mm
Aspect Ratio	0,0961
Roundness	0,0000
Symmetry	0,8560
Transparency	0,1525
Compactness	0,2961
Circularity	0,4566



Cam:0 Img:177 Part:1

Conv	0,9554
XcMin	0,0158 mm
XFeMax	0,2179 mm
ImageNo	177,0000
XMaMin	0,0140 mm
XInner	0,0150 mm
XArea	0,0602 mm
Aspect Ratio	0,0723
Roundness	0,6163
Symmetry	0,8701
Transparency	0,2311
Compactness	0,2765
Circularity	0,4141



Cam:0 Img:273 Part:1

Conv	0,9020
XcMin	0,0150 mm
XFeMax	0,2159 mm
ImageNo	273,0000
XMaMin	0,0143 mm
XInner	0,0142 mm
XArea	0,0558 mm
Aspect Ratio	0,0695
Roundness	0,0000
Symmetry	0,8135
Transparency	0,4136
Compactness	0,2585
Circularity	0,3674



Cam:0 Img:4 Part:11

Conv	0,9433
XcMin	0,0117 mm
XFeMax	0,2135 mm
ImageNo	4,0000
XMaMin	0,0090 mm
XInner	0,0109 mm
XArea	0,0490 mm
Aspect Ratio	0,0546
Roundness	0,5089
Symmetry	0,8720
Transparency	0,1295
Compactness	0,2294
Circularity	0,3461



Cam:0 Img:290 Part:15

Conv	0,9188
XcMin	0,0127 mm
XFeMax	0,2130 mm
ImageNo	290,0000
XMaMin	0,0099 mm
XInner	0,0117 mm
XArea	0,0503 mm
Aspect Ratio	0,0595
Roundness	0,0586
Symmetry	0,8874
Transparency	0,0900
Compactness	0,2360
Circularity	0,3560



Cam:0 Img:285 Part:7

Conv	0,9508
XcMin	0,0085 mm
XFeMax	0,2218 mm
ImageNo	285,0000
XMaMin	0,0084 mm
XInner	0,0077 mm
XArea	0,0442 mm
Aspect Ratio	0,0383
Roundness	0,6394
Symmetry	0,9137
Transparency	0,2446
Compactness	0,1990
Circularity	0,3112



Cam:0 Img:417 Part:1

Conv	0,9716
XcMin	0,0324 mm
XFeMax	0,2222 mm
ImageNo	417,0000
XMaMin	0,0304 mm
XInner	0,0315 mm
XArea	0,0876 mm
Aspect Ratio	0,1458
Roundness	0,2482
Symmetry	0,8898
Transparency	0,0323
Compactness	0,3941
Circularity	0,5855



Cam:0 Img:778 Part:1

Conv	0,9524
XcMin	0,0384 mm
XFeMax	0,2242 mm
ImageNo	778,0000
XMaMin	0,0362 mm
XInner	0,0376 mm
XArea	0,0846 mm
Aspect Ratio	0,1713
Roundness	0,1232
Symmetry	0,8512
Transparency	0,1985
Compactness	0,3774
Circularity	0,5376



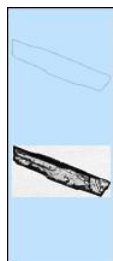
Cam:0 Img:170 Part:1

Conv	0,9803
XcMin	0,0351 mm
XFeMax	0,2249 mm
ImageNo	170,0000
XMaMin	0,0349 mm
XInner	0,0343 mm
XArea	0,0970 mm
Aspect Ratio	0,1561
Roundness	0,4451
Symmetry	0,9580
Transparency	0,0509
Compactness	0,4312
Circularity	0,6130



Cam:0 Img:525 Part:5

Conv	0,9347
XcMin	0,0224 mm
XFeMax	0,2574 mm
ImageNo	525,0000
XMaMin	0,0208 mm
XInner	0,0206 mm
XArea	0,0697 mm
Aspect Ratio	0,0869
Roundness	0,2944
Symmetry	0,8269
Transparency	0,3164
Compactness	0,2709
Circularity	0,4202



Cam:0 Img:192 Part:17

Conv	0,9797
XcMin	0,0494 mm
XFeMax	0,2464 mm
ImageNo	192,0000
XMaMin	0,0487 mm
XInner	0,0484 mm
XArea	0,1144 mm
Aspect Ratio	0,2006
Roundness	0,1129
Symmetry	0,9364
Transparency	0,3332
Compactness	0,4642
Circularity	0,6432



Cam:0 Img:199 Part:2

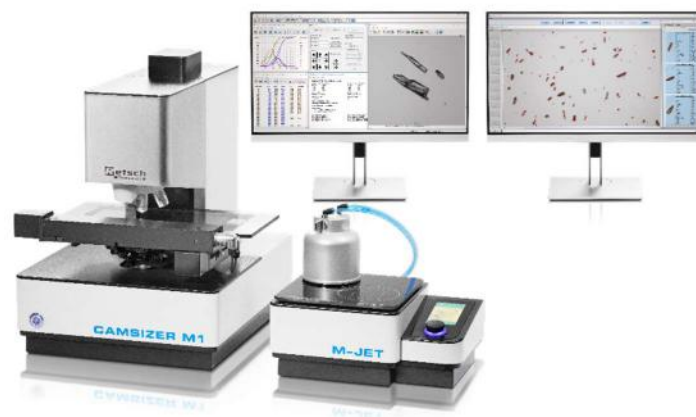
Conv	0,9718
XcMin	0,0450 mm
XFeMax	0,2438 mm
ImageNo	199,0000
XMaMin	0,0389 mm
XInner	0,0430 mm
XArea	0,1032 mm
Aspect Ratio	0,1845
Roundness	0,0602
Symmetry	0,8757
Transparency	0,0570
Compactness	0,4234
Circularity	0,6016

	Cam:0 Img:230 Part:1 Conv 0,9220 XcMin 0,0211 mm XFeMax 0,2615 mm ImageNo 230,0000 XMaMin 0,0176 mm XInner 0,0202 mm XArea 0,0749 mm Aspect Ratio 0,0806 Roundness 0,5321 Symmetry 0,8162 Transparency 0,2591 Compactness 0,2864 Circularity 0,4278		Cam:0 Img:692 Part:1 Conv 0,8816 XcMin 0,0131 mm XFeMax 0,2755 mm ImageNo 692,0000 XMaMin 0,0090 mm XInner 0,0122 mm XArea 0,0566 mm Aspect Ratio 0,0474 Roundness 0,4961 Symmetry 0,6835 Transparency 0,2265 Compactness 0,2055 Circularity 0,3176		Cam:0 Img:51 Part:9 Conv 0,9727 XcMin 0,0364 mm XFeMax 0,2799 mm ImageNo 51,0000 XMaMin 0,0333 mm XInner 0,0353 mm XArea 0,1018 mm Aspect Ratio 0,1301 Roundness 0,0895 Symmetry 0,8892 Transparency 0,0710 Compactness 0,3637 Circularity 0,5517
	Cam:0 Img:556 Part:1 Conv 0,9745 XcMin 0,0211 mm XFeMax 0,2858 mm ImageNo 556,0000 XMaMin 0,0198 mm XInner 0,0202 mm XArea 0,0782 mm Aspect Ratio 0,0738 Roundness 0,2804 Symmetry 0,9493 Transparency 0,2668 Compactness 0,2735 Circularity 0,4180		Cam:0 Img:239 Part:12 Conv 0,9595 XcMin 0,0358 mm XFeMax 0,3224 mm ImageNo 239,0000 XMaMin 0,0289 mm XInner 0,0348 mm XArea 0,1082 mm Aspect Ratio 0,1110 Roundness 0,2127 Symmetry 0,8539 Transparency 0,0688 Compactness 0,3355 Circularity 0,4888		Cam:0 Img:469 Part:1 Conv 0,9432 XcMin 0,0133 mm XFeMax 0,3026 mm ImageNo 469,0000 XMaMin 0,0115 mm XInner 0,0125 mm XArea 0,0629 mm Aspect Ratio 0,0438 Roundness 0,5014 Symmetry 0,8663 Transparency 0,1914 Compactness 0,2078 Circularity 0,3176
	Cam:0 Img:39 Part:1 Conv 0,9736 XcMin 0,0222 mm XFeMax 0,2956 mm ImageNo 39,0000 XMaMin 0,0218 mm XInner 0,0213 mm XArea 0,0807 mm Aspect Ratio 0,0751 Roundness 0,0000 Symmetry 0,9121 Transparency 0,2212 Compactness 0,2730 Circularity 0,4245		Cam:0 Img:146 Part:12 Conv 0,9365 XcMin 0,0106 mm XFeMax 0,2938 mm ImageNo 146,0000 XMaMin 0,0100 mm XInner 0,0099 mm XArea 0,0551 mm Aspect Ratio 0,0360 Roundness 0,1354 Symmetry 0,8044 Transparency 0,0481 Compactness 0,1876 Circularity 0,2987		Cam:0 Img:671 Part:5 Conv 0,9472 XcMin 0,0087 mm XFeMax 0,3352 mm ImageNo 671,0000 XMaMin 0,0081 mm XInner 0,0080 mm XArea 0,0534 mm Aspect Ratio 0,0260 Roundness 0,0000 Symmetry 0,8181 Transparency 0,0637 Compactness 0,1592 Circularity 0,2479
	Cam:0 Img:762 Part:2 Conv 0,8757 XcMin 0,0292 mm XFeMax 0,3731 mm ImageNo 762,0000 XMaMin 0,0142 mm XInner 0,0231 mm XArea 0,0915 mm Aspect Ratio 0,0782 Roundness 0,4789 Symmetry 0,6750 Transparency 0,1056 Compactness 0,2452 Circularity 0,3771		Cam:0 Img:624 Part:17 Conv 0,9552 XcMin 0,0239 mm XFeMax 0,4070 mm ImageNo 624,0000 XMaMin 0,0226 mm XInner 0,0233 mm XArea 0,1026 mm Aspect Ratio 0,0586 Roundness 0,1465 Symmetry 0,8738 Transparency 0,0342 Compactness 0,2521 Circularity 0,3925		Cam:0 Img:810 Part:1 Conv 0,9266 XcMin 0,0158 mm XFeMax 0,4539 mm ImageNo 810,0000 XMaMin 0,0148 mm XInner 0,0154 mm XArea 0,0808 mm Aspect Ratio 0,0347 Roundness 0,0000 Symmetry 0,8997 Transparency 0,0556 Compactness 0,1779 Circularity 0,2812

Fig. 10: The 30 longest particles of sample 2

CAMSIZER M1: benefits at a glance

- Static image analysis (ISO 13322-1) from 0,5 μm – 1500 μm
- 18.1 Megapixel camera
- Up to six objective lenses
- Transmitted and reflected light
- High precision sample stage
- Max. digital resolution: 35 nm
- M-Jet dispersion module
- Particle X-Plorer Software
- Precise analysis of small particles



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