

# Analyze 12.0

## Bone Microarchitecture Analysis Add-on

The Bone Microarchitecture Analysis (BMA) is a powerful pre-clinical research application designed for the evaluation of 3D microCT image data. The module provides researchers the ability to process single whole bone specimens and isolated 3D samples of trabecular tissue. It generates an extensive set of bone morphometric indices as described by Bouxsein *et al* \*.



The BMA add-on provides automatic and user-guided isolation of bone from non-bone tissue by means of threshold based segmentation and a novel segmentation process. This process also provides for the separation of the cortical and trabecular bone in whole bone specimens. BMA uses the segmented regions to automatically drive the calculation of common bone morphometric indices that provide researchers with a quantitative description of bone microarchitecture. The microarchitectural characteristics of the trabecular and cortical bone are listed below (table 1 and 2).

**Table 1. Trabecular Bone Morphometric Indices**

Abbreviation	Description	Unit
TV	Total Volume	mm <sup>3</sup>
BV	Bone Volume	mm <sup>3</sup>
BS	Bone Surface	mm <sup>2</sup>
BV/TV	Bone Volume Fraction	%
BS/TV	Bone Surface Density	mm <sup>2</sup> /mm <sup>3</sup>
BS/BV	Specific Bone Surface	mm <sup>2</sup> /mm <sup>3</sup>
Conn.D	Connectivity Density	1/mm <sup>3</sup>
SMI	Structure Model Index	
Tb.N	Trabecular Number	1/mm
Tb.Th	Trabecular Thickness	mm
Tb.Sp	Trabecular Separation	mm
Tb.Th.SD	Standard Deviation of Trabecular Thickness	mm
Tb.Sp.SD	Standard Deviation of Trabecular Separation	mm
DA	Degree of Anisotropy	
MIL	Mean Intercept Length	

**Table 2. Cortical Bone Morphometric Indices**

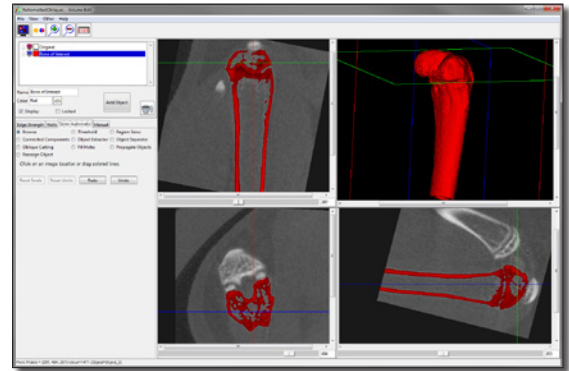
Abbreviation	Description	Unit
Tt.Ar	Total Cross-Sectional Area	mm <sup>2</sup>
Ct.Ar	Cortical Bone Area	mm <sup>2</sup>
Ma.Ar	Medullary Area	mm <sup>2</sup>
Ct.Ar/Tt.Ar	Cortical Area Fraction	%
Ct.Th	Average Cortical Thickness	mm
Ps.Pm	Periosteal perimeter	mm
Ec.Pm	Endocortical Perimeter	mm
$I_{ap}$	Moment of Inertia Anteroposterior Axis	mm <sup>4</sup>
$I_{ml}$	Moment of Inertia Mediolateral Axis	mm <sup>4</sup>
$I_{max}$	Maximum Moment of Inertia	mm <sup>4</sup>
$I_{min}$	Minimum Moment of Inertia	mm <sup>4</sup>
J	Polar Moment of Inertia	mm <sup>4</sup>
Ct.Po	Cortical Porosity	%
Po.N	Pore Number	n
Po.V	Total Pore Volume	mm <sup>3</sup>
AvgPo.V	Average Pore Volume	mm <sup>3</sup>
Po.V.SD	Standard Deviation of Pore Volume	mm <sup>3</sup>
Po.Dn	Pore Density	1/mm <sup>3</sup>

\*Bouxsein, M. L., Boyd, S. K., Christiansen, B. A., Guldborg, R. E., Jepsen, K. J., & Muller, R. Guidelines for Assessment of Bone Microstructure in Rodents Using Micro-Computed Tomography. *Journal of Bone and Mineral Research*, 25, 1468-1486.

# Bone Microarchitecture Analysis Workflow

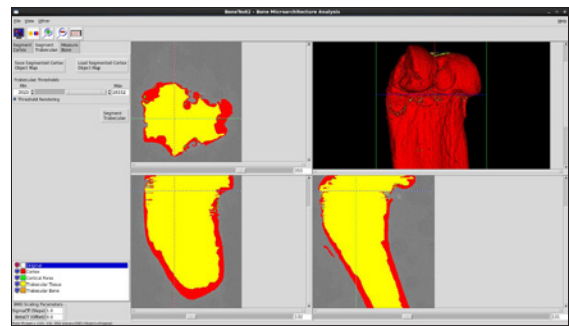
## Preprocessing

The BMA add-on module requires that bone specimens are isovolumetric. If the image data contains multiple bones the bone of interest must be isolated and orientated into the correct anatomical orientation. All tools needed for data preprocessing are provided with Analyze 12.0.



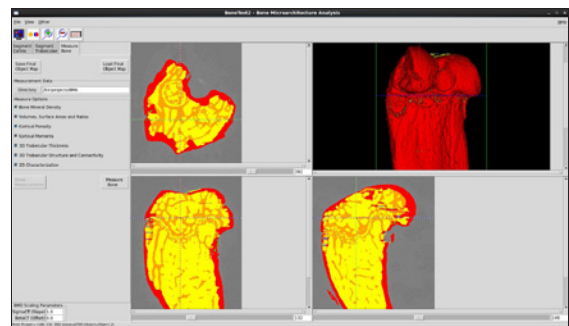
## Cortical Bone Segmentation

Once the image data is loaded the BMA add-on will conduct a preliminary segmentation which will allow the module to identify the cortical shell, cortical pores and trabecular tissue regions.



## Trabecular Bone Segmentation

Upon user approval the add-on will now complete the segmentation process by identifying the trabecular bone in the trabecular region. Two new regions, the trabecular bone and intra-trabecular space will be derived.



## Calculate Bone Morphometric Indices

Measurements are automatically calculated for the trabecular and cortical bone and output in several comma-separated value (.csv) files. A utility is also provided to convert CT numbers (HUs) to Bone Mineral Density (BMD) in units of mg/CC.

Site	TLAR	CLAR	MBAR	CLAR/TLAR	CL/TL	FL/PM	S.P.M	TS.N	DA	MBL
1	2.2051	0.8884	1.2632	43.0146	0.2393	0.2088	3.0822	6.6663	496.5262	0.3376
2	2.2056	0.8465	1.2561	43.3689	0.2360	0.2019	3.1343	6.6432	360.6364	0.3435
3	2.2062	0.8466	1.2576	42.9664	0.2385	0.2098	3.1072	6.3296	337.9501	0.3433
4	2.2162	0.8823	1.2620	42.8715	0.2378	0.2169	3.1061	6.6065	443.5165	0.3488
5	2.2121	0.8470	1.2648	42.8130	0.2376	0.2156	3.1395	6.6312	341.5024	0.3452
6	2.2162	0.8466	1.2624	42.8622	0.2379	0.2169	3.0514	6.5600	325.3363	0.3404
7	2.2182	0.8459	1.2722	42.6441	0.2346	0.2221	3.1046	5.5325	354.4988	0.3467
8	2.2180	0.8456	1.2744	42.7648	0.2365	0.2064	3.1225	5.6028	312.0733	0.3345
9	2.2224	0.8429	1.2796	42.4248	0.2351	0.2021	3.2060	5.3277	338.2115	0.3390
10	2.2280	0.8420	1.2776	42.7648	0.2368	0.2021	3.1344	5.4468	242.3364	0.3344
11	2.2287	0.8468	1.2819	42.4835	0.2359	0.1768	3.1662	5.2817	389.4519	0.3493
12	2.2296	0.8441	1.2857	42.3660	0.2348	0.2021	3.1881	5.1752	311.1199	0.3360
13	2.2337	0.8461	1.2875	42.3544	0.2352	0.1768	3.1544	5.0945	347.1531	0.3540
14	2.2363	0.8456	1.2923	42.2811	0.2348	0.2021	3.1823	5.0623	280.4880	0.3411
15	2.2422	0.8465	1.2975	42.1372	0.2339	0.2021	3.3021	5.1754	265.2679	0.3516
16	2.2424	0.8377	1.3057	42.7077	0.2315	0.3099	3.1615	5.4306	399.8229	0.3551
17	2.2462	0.8361	1.3080	41.7888	0.2314	0.1768	3.1369	5.2819	277.4962	0.3478
18	2.2474	0.8367	1.3108	41.8737	0.2308	0.3051	3.1354	5.5787	562.3824	0.3598
19	2.2527	0.8461	1.3125	41.7115	0.2315	0.3026	3.1265	5.6525	512.8154	0.3483
20	2.2560	0.8425	1.3124	42.8218	0.2329	0.4332	3.1430	5.7400	598.2126	0.3498
21	2.2602	0.8362	1.3078	42.7619	0.2344	0.4876	3.0863	5.4262	363.1863	0.3464
22	2.2620	0.8316	1.3098	42.8076	0.2346	0.4304	3.0480	5.9031	278.8793	0.3388
23	2.2698	0.8302	1.3101	42.1762	0.2350	0.4071	3.0514	5.7287	298.9689	0.3397
24	2.2674	0.8314	1.3160	42.2250	0.2340	0.4291	3.0968	5.7293	354.1145	0.3393
25	2.2718	0.8316	1.3261	41.8859	0.2336	0.4439	3.1110	5.6351	221.9579	0.3364
26	2.2747	0.8333	1.3212	41.9306	0.2343	0.4863	3.1118	5.9527	243.0177	0.3442