European Geosciences Union - General Assembly 2011 - Vienna, Austria, 3 – 8 April 2011
SSS5.6 – Digital soil mapping: novel approaches (including geophysical measurement, micromorphology) to the prediction of key soil properties for modelling physical processes

Soil fauna activity and soil porosity: characterization by micromorphological image analysis

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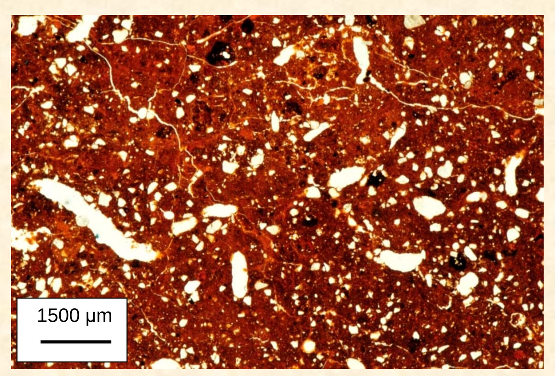
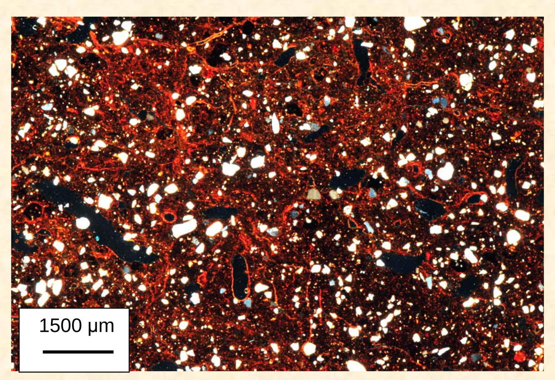
The soil biological communities are characterized by a higher diversity, by several orders of magnitude, compared to aboveground biomass. Soil fauna and plant roots play an important role in the formation and stabilization of soil structure, and the organization of the pore system influences soil flows and soil functions. The most significant effects of soil organisms on the soil structure are due to their activities as soil engineers through their burrowing and excreting activities.
Soil micromorphology provides the opportunity for investigating fauna–soil relationships since evidence of animal activities such as burrowing and deposition of excrement (faecal pellets) can be identified and quantified. Image analysis techniques allow direct investigations of the soil pore system and provide valid tools to quantitatively analyze both shape and size distribution of pores.
The goals of this preliminary work were the identification and analysis of specific signs of biological activity and the quantification of their effects on soil pore system.


Using a large collection of thin sections from very different soil types, microsites with specific signs of biological activities were detected and their images acquired under transmitted light (TL) and circular polarized light (CPL).

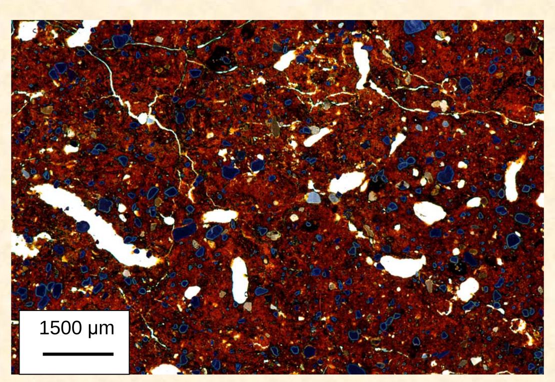
TL image



CPL image



Difference image

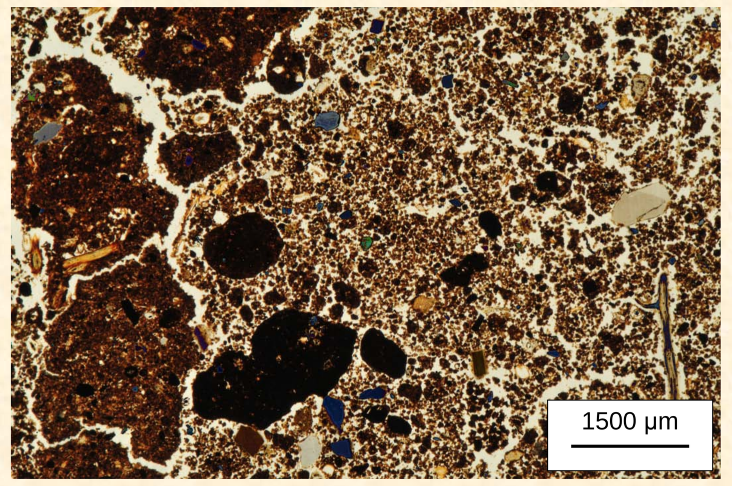


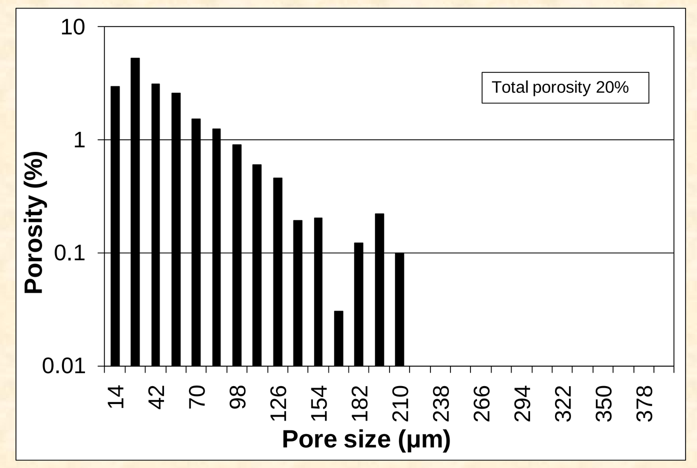
The difference between the two images was used to discriminate between pores and mineral grains, The resulted image was analysed.

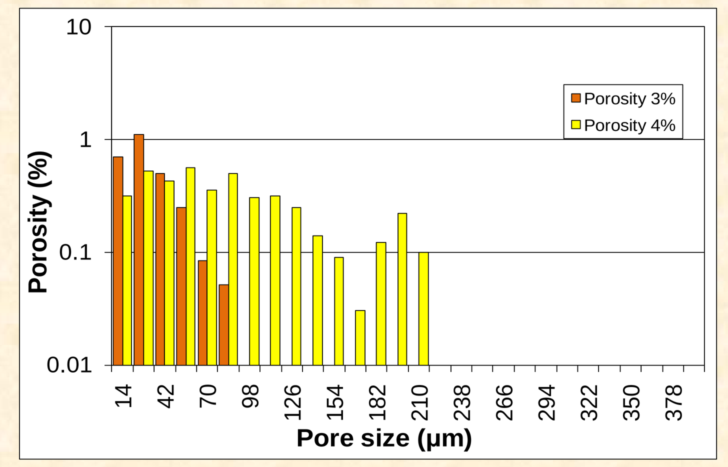
Pore Size Distribution

Pore size distribution was determined by image analysis using Micromorph 1.4, through the application of the "opening" algorithm, which classifies the pore phase relative to the spacing from the walls.

Earthworm excrement





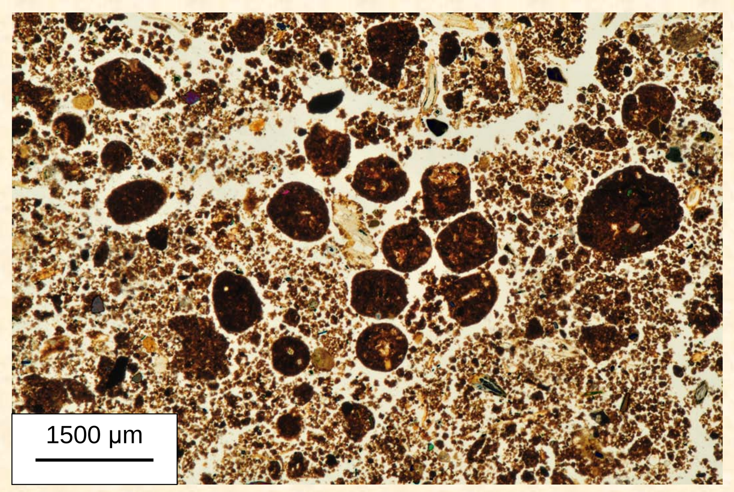


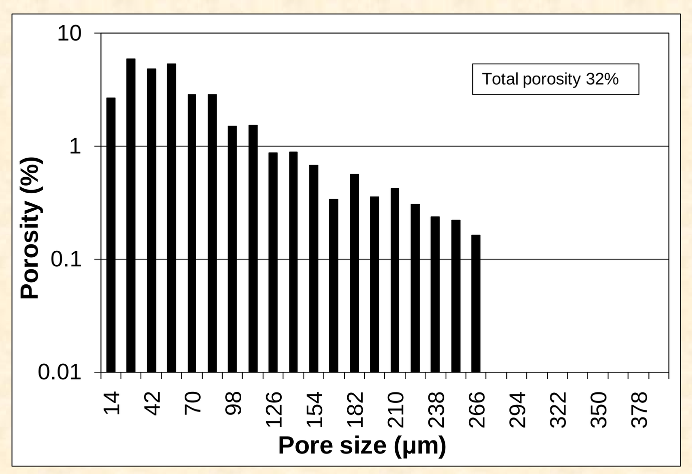
Pores of total image

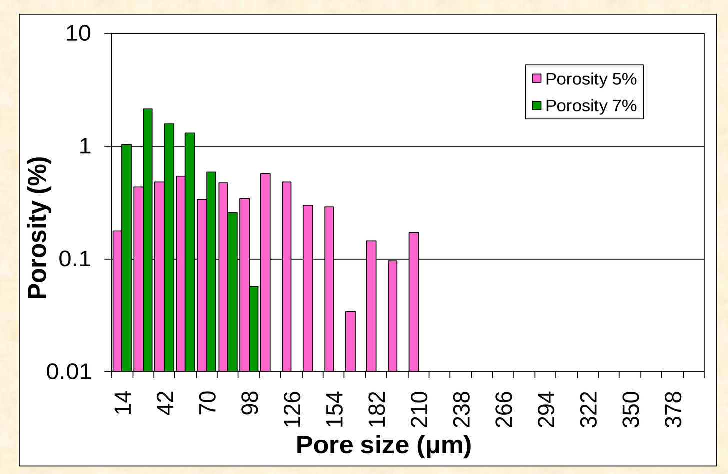
Pores produced by earthworm activities

Pores produced by enchytraeid activities

Faecal pellets





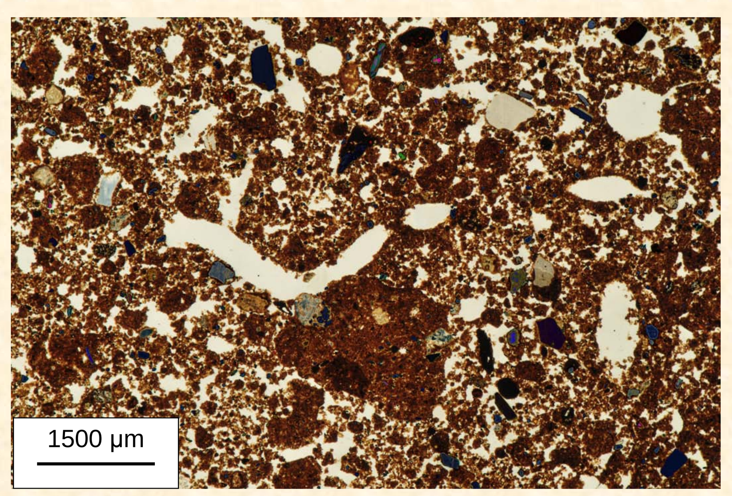


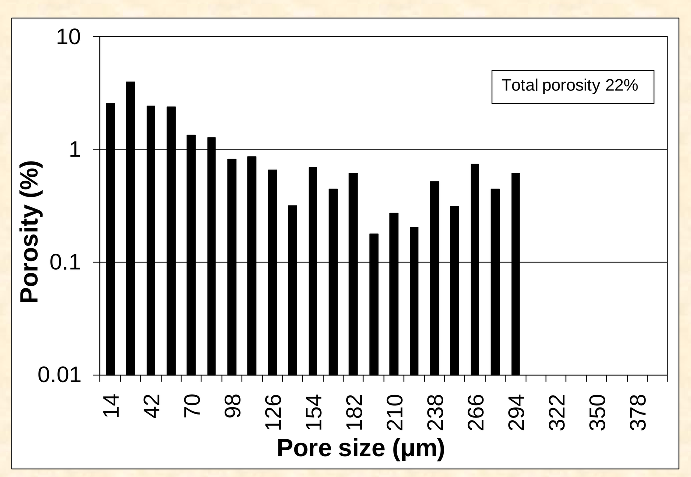
Pores of total image

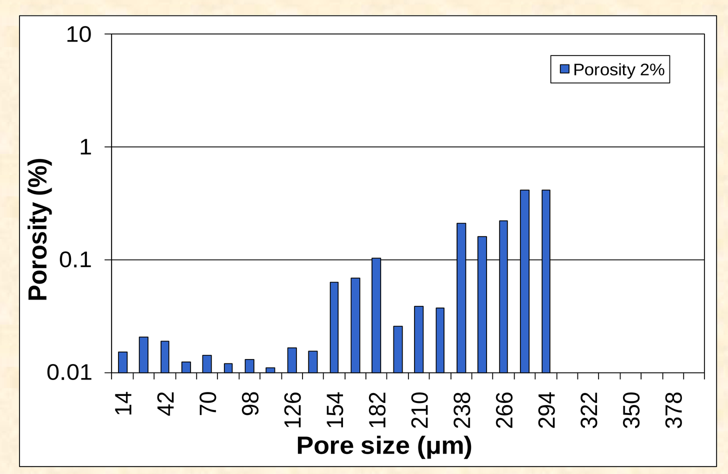
Pores produced by beetle larvae activities

Pores produced by enchytraeid activities

Faunal passage



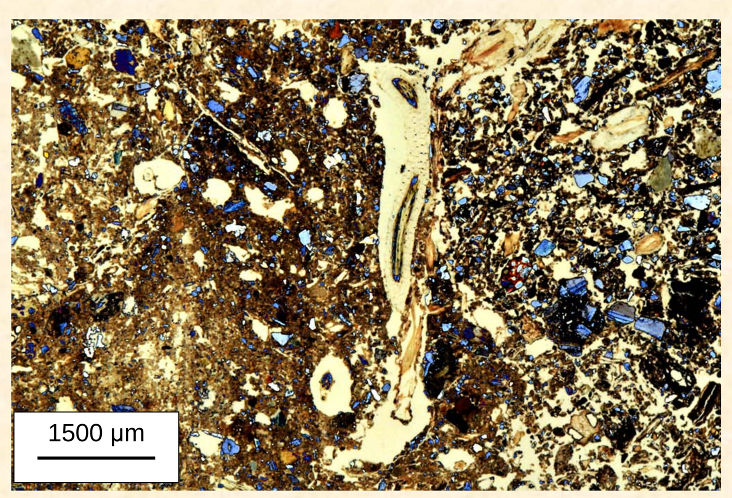


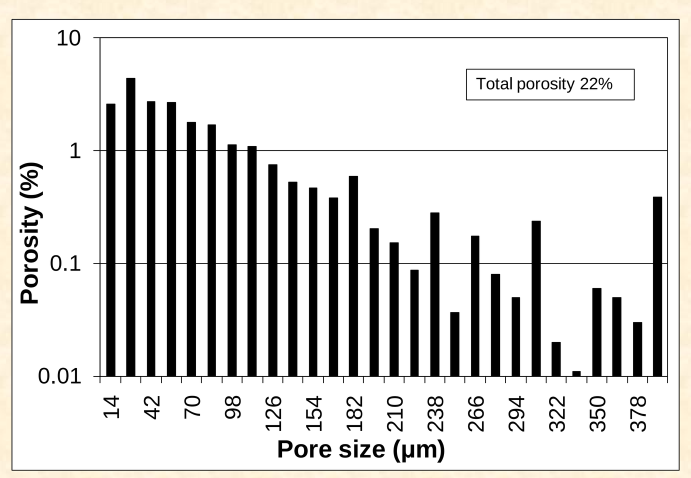


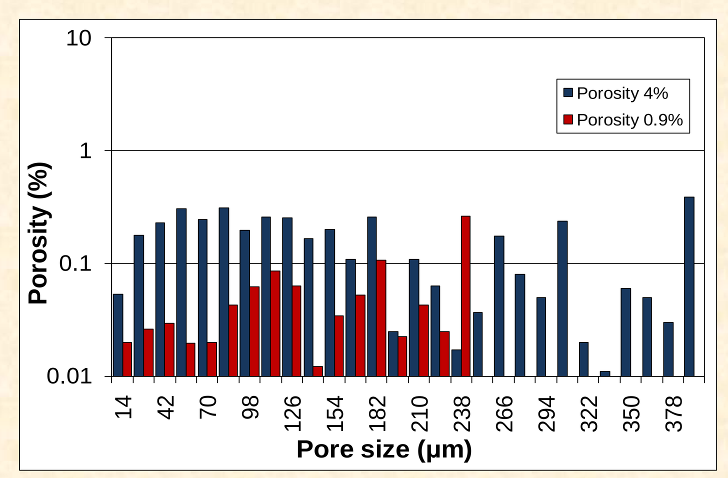
Pores of total image

Pores produced by faunal passage

Plant roots







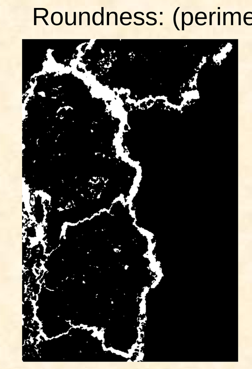
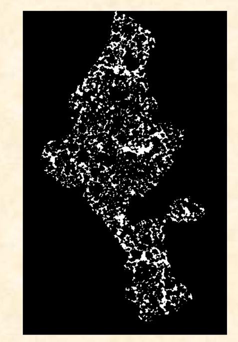
Pores of total image

Pores produced by longitudinal section of plant roots

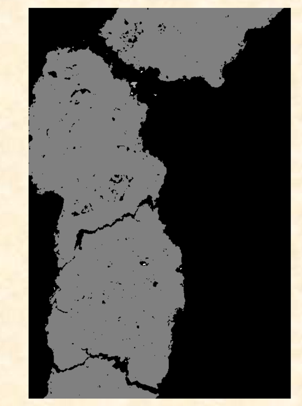
Pores produced by trasversal section of plant roots

Object analysis

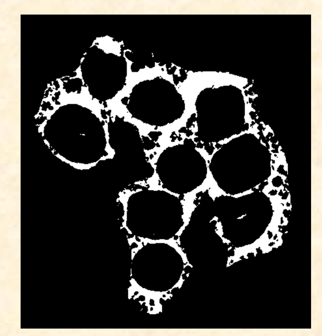
Each biological feature was isolated and studied by morphometric object analysis using Image-Pro Plus 6.0, in order to calculate its morphometric parameters.
Aspect: ratio between major axis and minor axis of ellipse equivalent to object.
Area/Box: ratio between area of object and area of its bounding box.
Radius ratio: ratio between maximum radius and minimum radius.
Roundness: (perimeter^2)/(4*π*area).

Morphometric parameter	Mean value
Area (μm^2)	2857220
Aspect	1.39
Area/Box	0.61
Mean Diameter (μm)	1873
Holes	23.50
Radius Ratio	2.14
Roundness	4.94

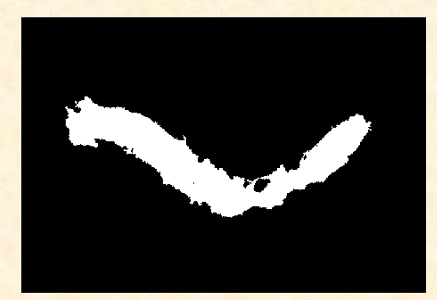


Morphometric parameters of earthworm excrement



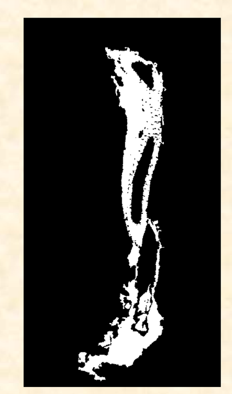

Morphometric parameter	Mean value
Area (μm^2)	287869
Aspect	1.20
Area/Box	0.72
Mean Diameter (μm)	586
Holes	7.71
Radius Ratio	1.44
Roundness	2.56

Morphometric parameters of faecal pellets of beetle larvae

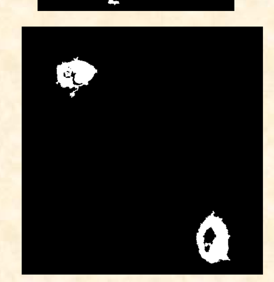


Morphometric parameter	Mean value
Area (μm^2)	711040
Aspect	3.33
Area/Box	0.31
Mean Diameter (μm)	1220
Holes	4
Radius Ratio	77.50
Roundness	9.24

Morphometric parameters of pore produced by faunal passage



Morphometric parameter	Mean value
Area (μm^2)	1464809
Aspect	6.90
Area/Box	0.28
Mean Diameter (μm)	1087
Holes	114
Radius Ratio	17.29
Roundness	82.66

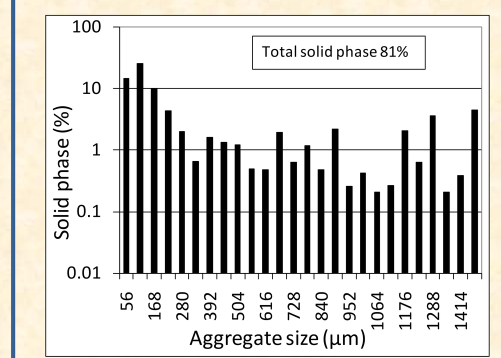


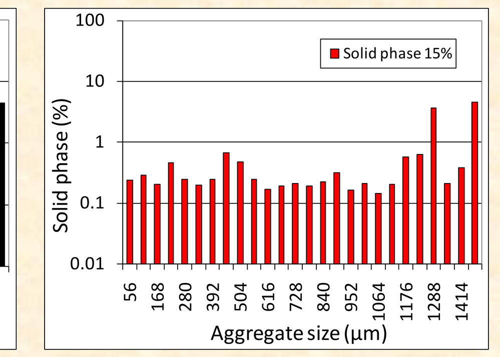
Morphometric parameter	Mean value
Area (μm^2)	168683
Aspect	1.42
Area/Box	0.54
Mean Diameter (μm)	477
Holes	5.50
Radius Ratio	1.99
Roundness	6.45

Morphometric parameters of pore produced by fragment of plant root

Aggregate size distribution

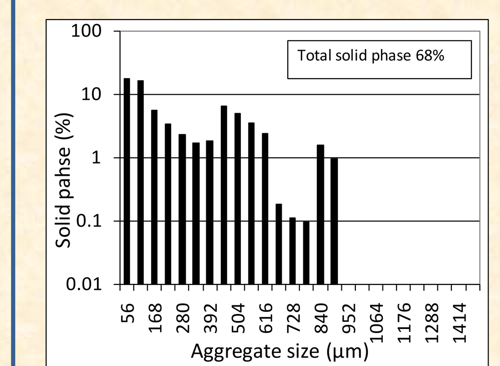
For biological features such as earthworm excrement and faecal pellets also the aggregate size distribution of total image and of biological feature were analysed.

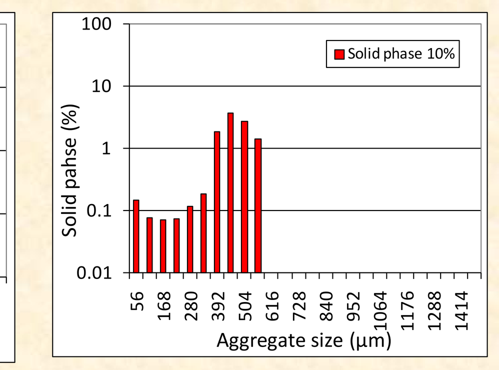




Aggregate of total image

Aggregate of earthworm excrement





Aggregate of total image

Aggregate of faecal pellets of beetle larvae

Results showed, overall, that the contribution to the porosity due to biological activity can be easier detected when it produces large pores, but specific signals in pore size distribution are also present in the micropore range, as in the case of enchytraeid activity. Earthworm and beetle larve induce pores development in the same size range, but they produce more specific signals in the aggregate size distribution, therefore in some cases morphometry of solid phase is more useful for biological activity detection. The morphometric parameters determined by the object analysis that better allow to discriminate among different biological features are resulted aspect (for the longitudinal section of plant roots), radius ratio (for the faunal passage) and roundness (for feacal pellets). .

This preliminary work allowed to discriminate the contribution of different biological activities to the soil pore system. Fragment of plant roots, faunal passages, faecal pellets and earthworm excrements produce specific pore size distribution signals.
It is important to emphasise that the combination of different biological activities in the same soil produce a pronounced multimodal pore size distribution; this finding is much important for the fertility of soils.
The image analysis of soild phase also can be used to identify the effects of the faecal material on soil structure. In fact faecal pellets and earthworm excrement produce more evident and different signals in aggregate size distribution.
The object analysis allowed to identify the morphometric parameters that better describe specific morphological characteristics of different biological features. These parameters can be used to discriminate among different biological activities in the soil.