- A Statistical Approach to Identify Mobile Particles of Widely Graded Soils -

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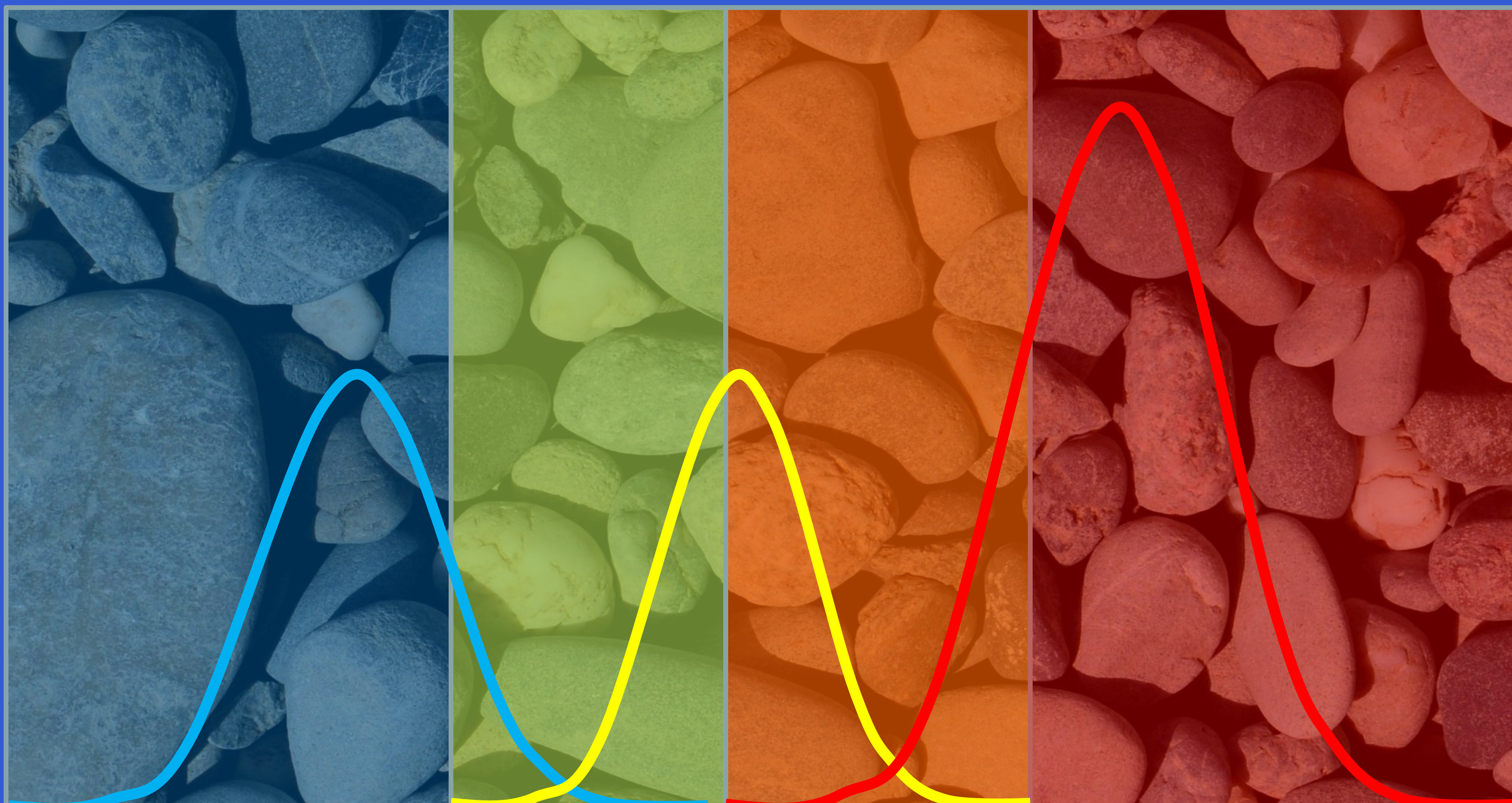
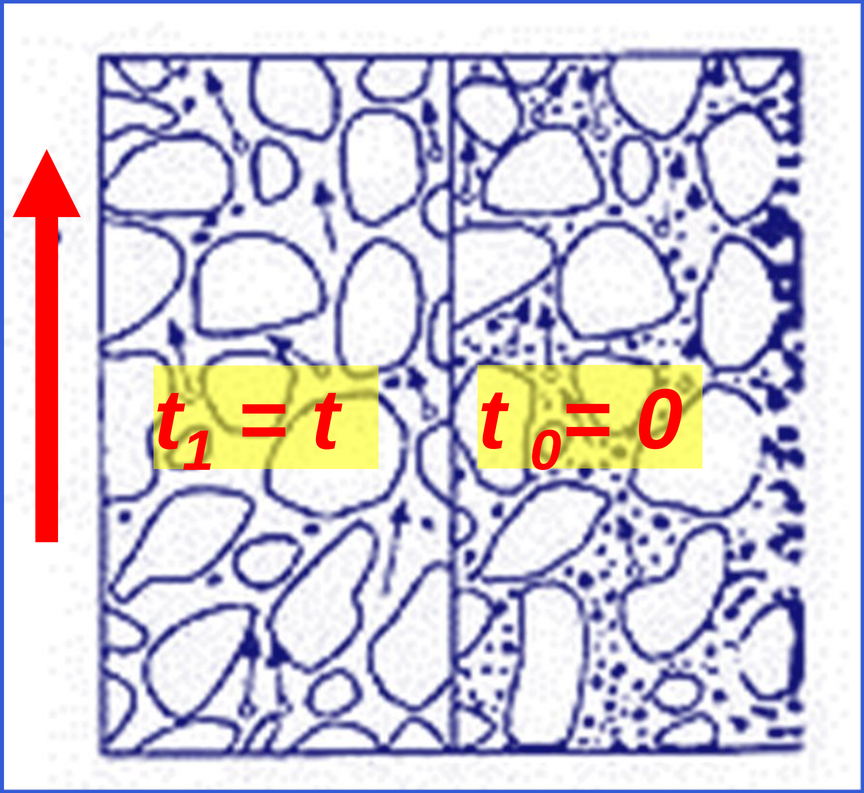
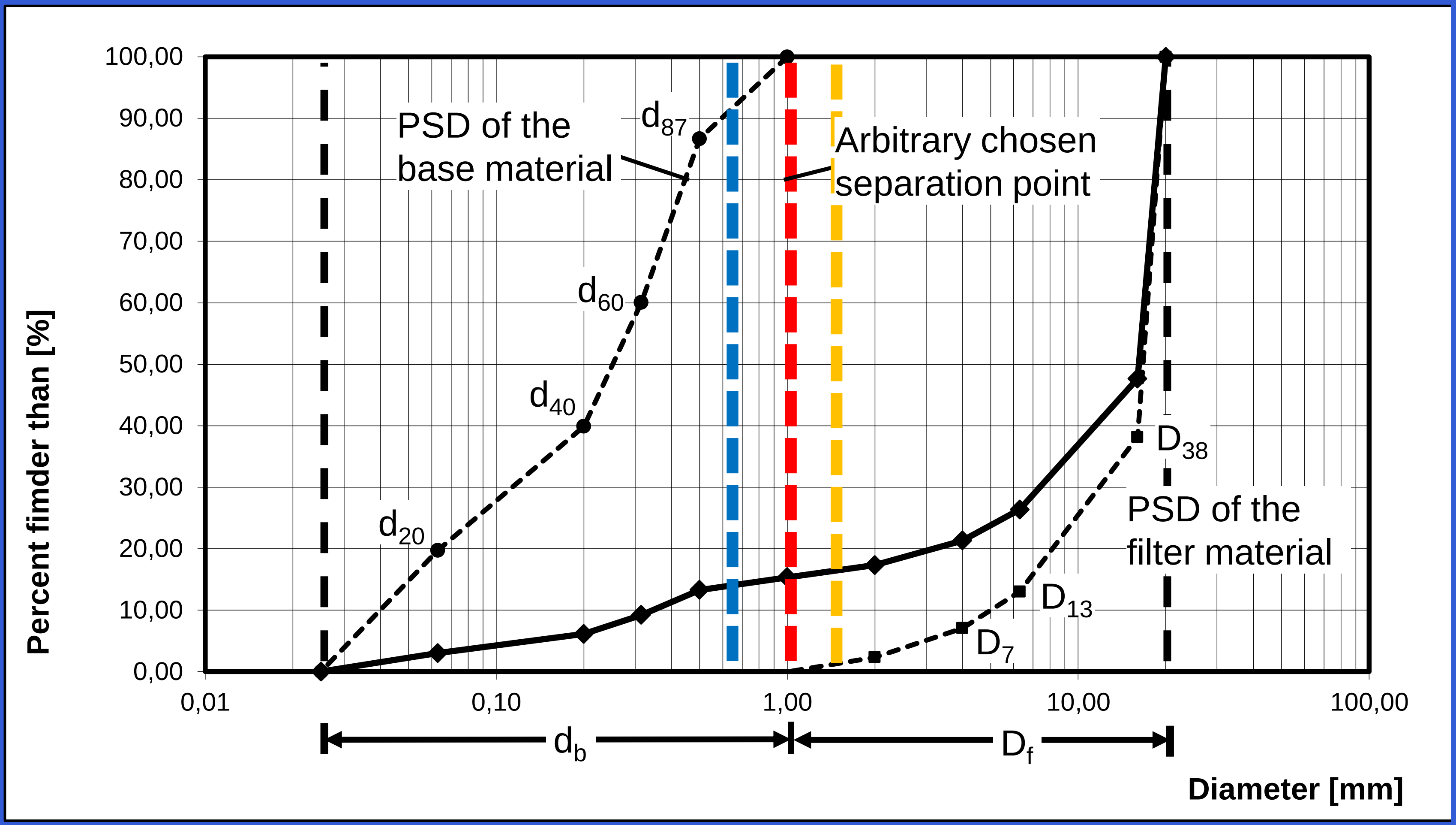


Objective of the study

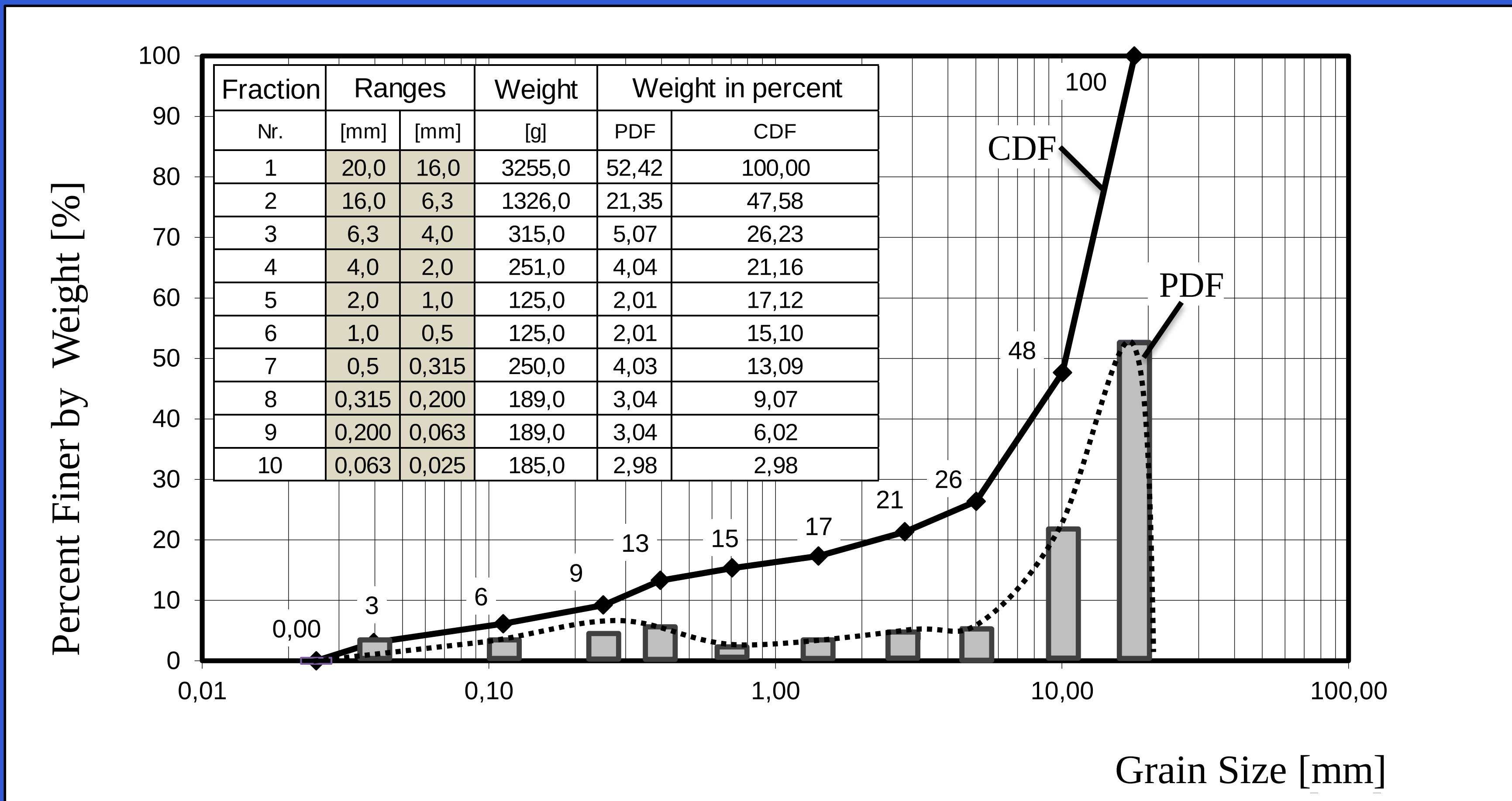


Left: a widely graded soil ; Right: the changes of the soil structure due to water flow

Motivation for quantifying the mobile particles



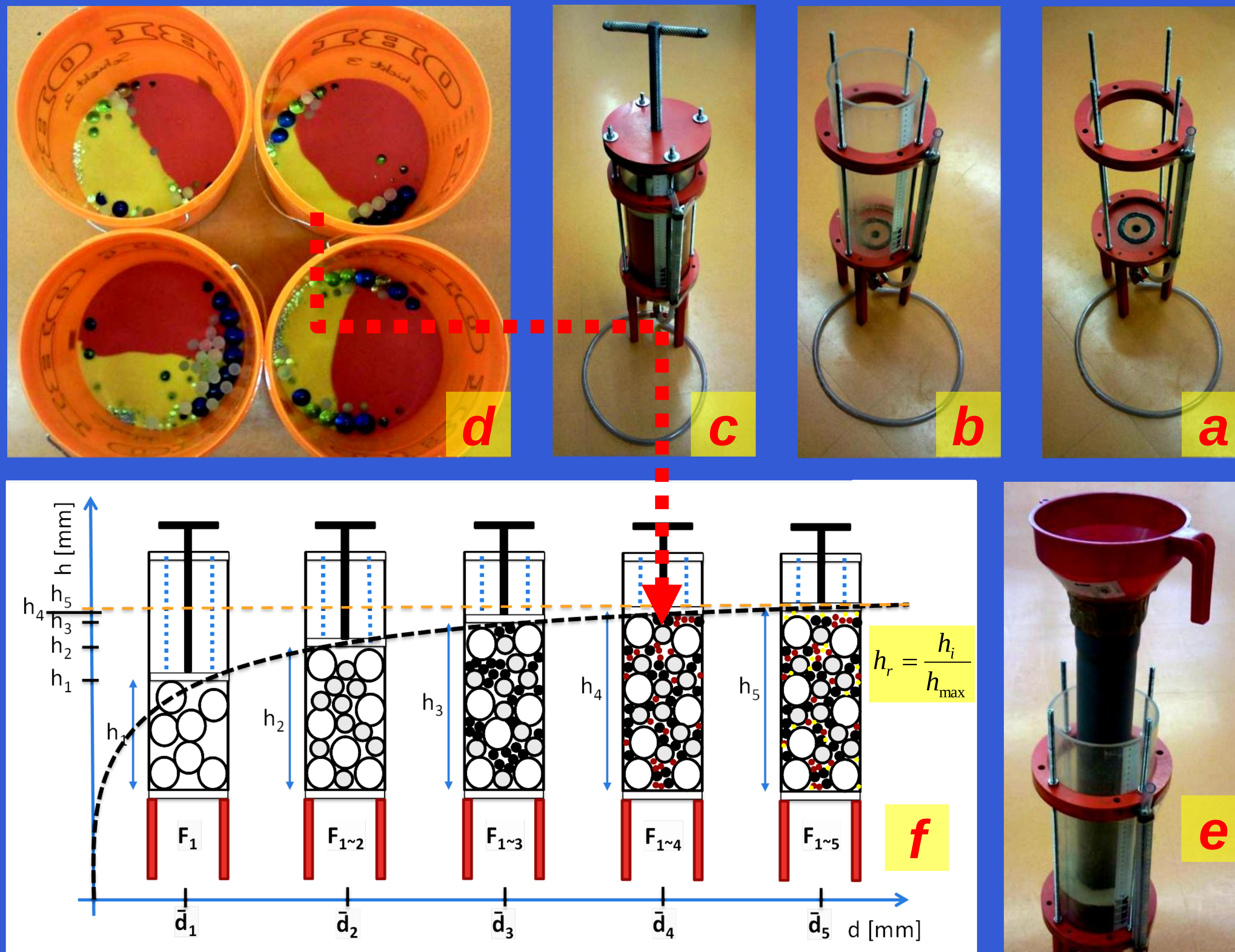
Material



Fraction	Ranges		Weight	Weight in percent	
Nr.	[mm]	[mm]	[g]	PDF	CDF
1	20,0	16,0	3255,0	52,42	100,00
2	16,0	6,3	1326,0	21,35	47,58
3	6,3	4,0	315,0	5,07	26,23
4	4,0	2,0	251,0	4,04	21,16
5	2,0	1,0	125,0	2,01	17,12
6	1,0	0,5	125,0	2,01	15,10
7	0,5	0,315	250,0	4,03	13,09
8	0,315	0,200	189,0	3,04	9,07
9	0,200	0,063	189,0	3,04	6,02
10	0,063	0,025	185,0	2,98	2,98

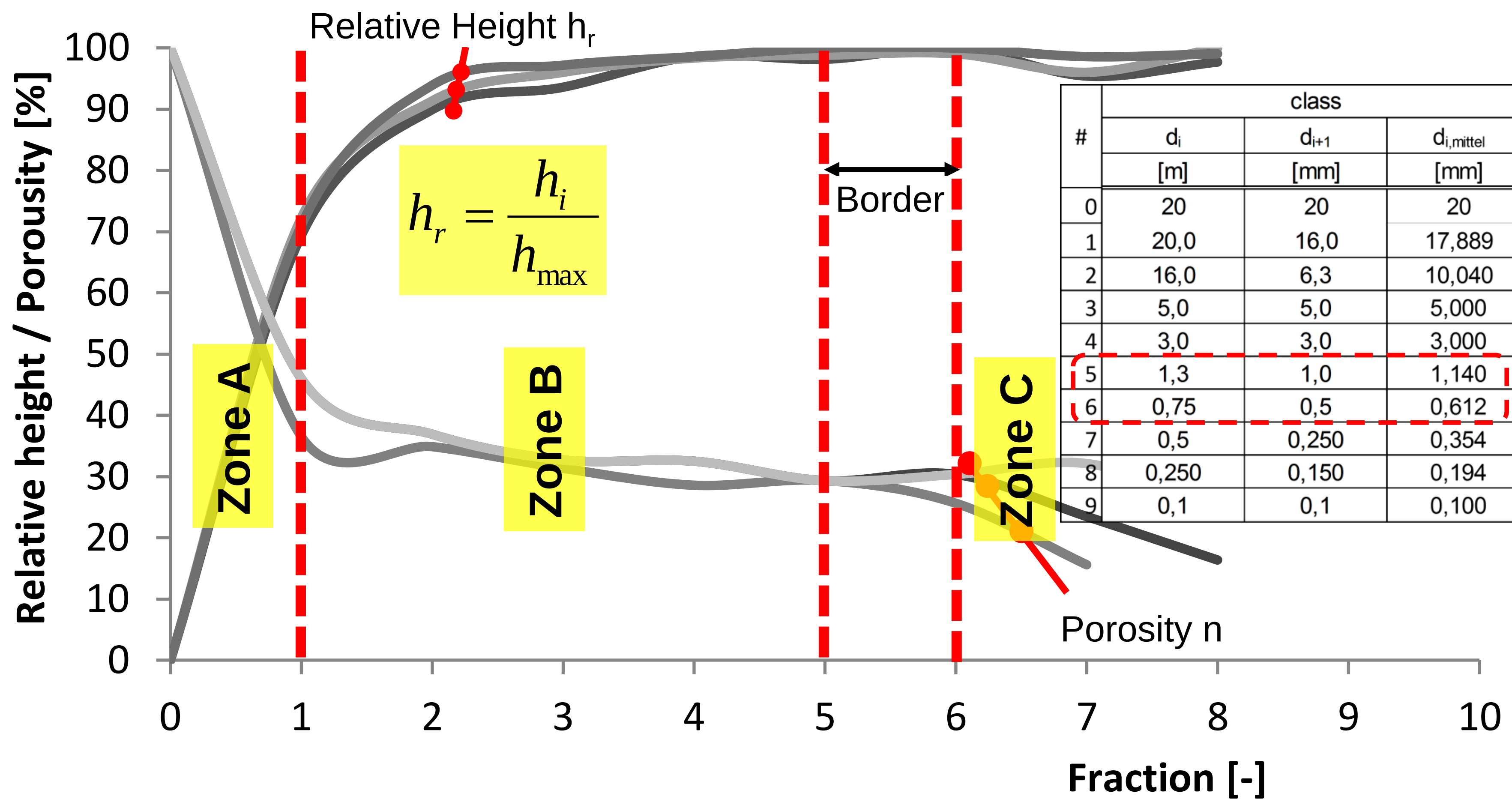
Particle size distribution of investigated soil and Probability density function of its fractions ; CDF: Cumulative Distribution Function ~ PSD, PDF: Probability Distribution Function

Experimental Procedure



[Burenkova 1993 & Binner et al. 2010].

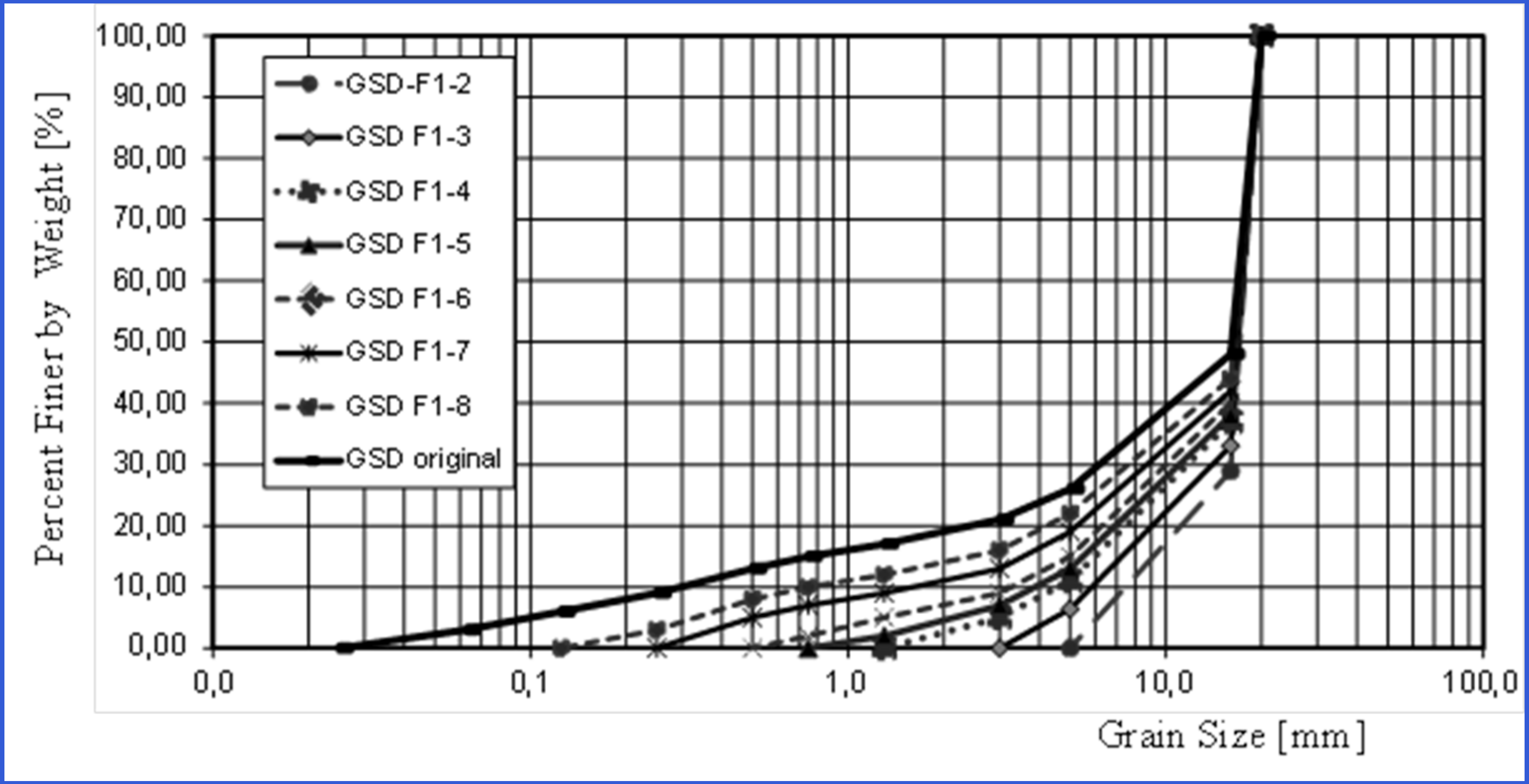
Test Result



#	class		
	d_i	d_{i+1}	$d_{i,mittel}$
	[m]	[mm]	[mm]
0	20	20	20
1	20,0	16,0	17,889
2	16,0	6,3	10,040
3	5,0	5,0	5,000
4	3,0	3,0	3,000
5	1,3	1,0	1,140
6	0,75	0,5	0,612
7	0,5	0,250	0,354
8	0,250	0,150	0,194
9	0,1	0,1	0,100

The results of three sequential fill tests (SFT) on the investigated soil

Cluster Analysis R-*kmeans*

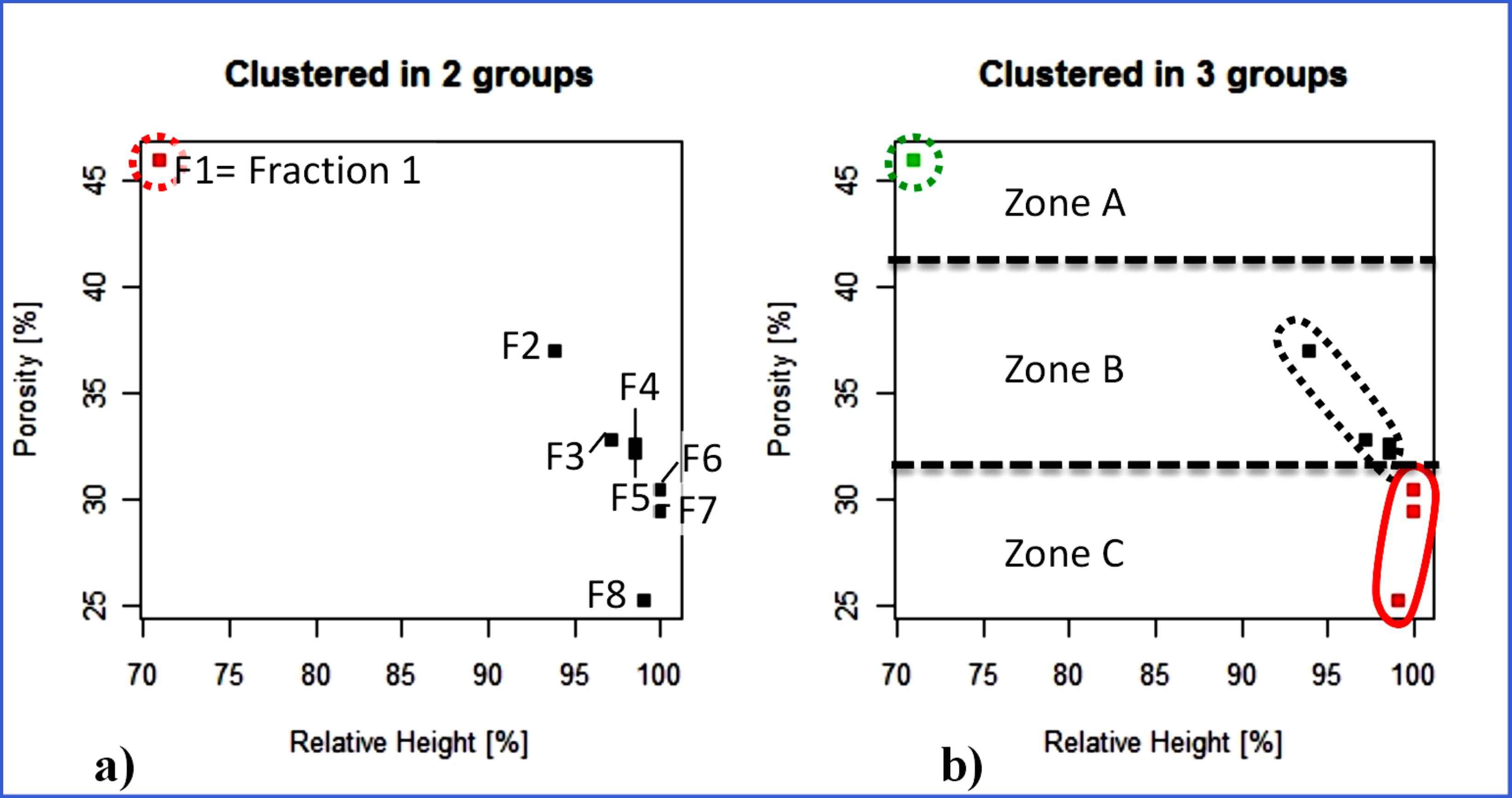


$$\underset{\mathbf{S}}{\arg\min} \sum_{i=1}^{k} \sum_{\mathbf{x}_j \in S_i} \left\| \mathbf{x}_j - \boldsymbol{\mu}_i \right\|^2$$

$\mathbf{S} = \{S_1, S_2, \ldots, S_k\}$ so as to minimize the within-cluster sum of squares (WCSS):

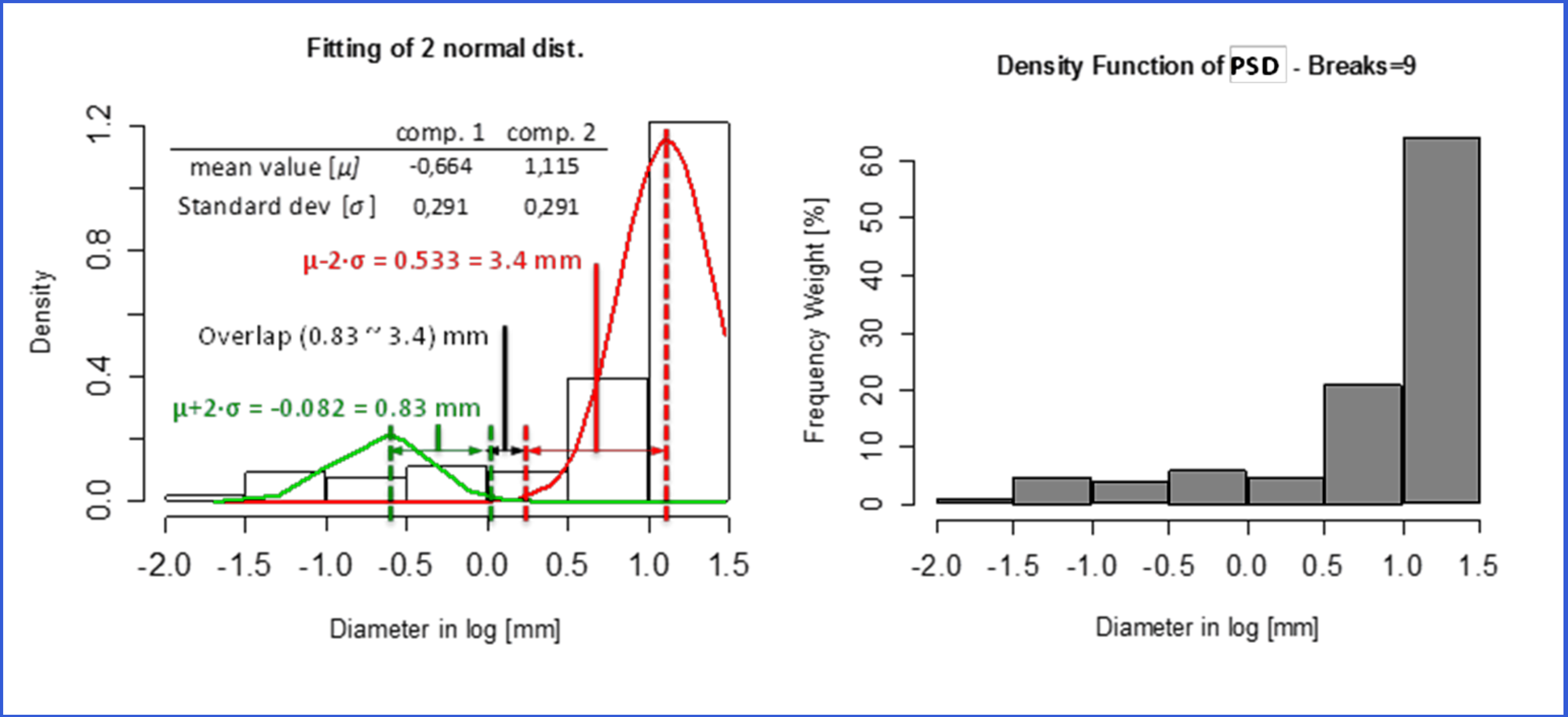
where $\boldsymbol{\mu}_i$ is the mean of points in S_i.

Cluster Analysis R-*Kmeans*



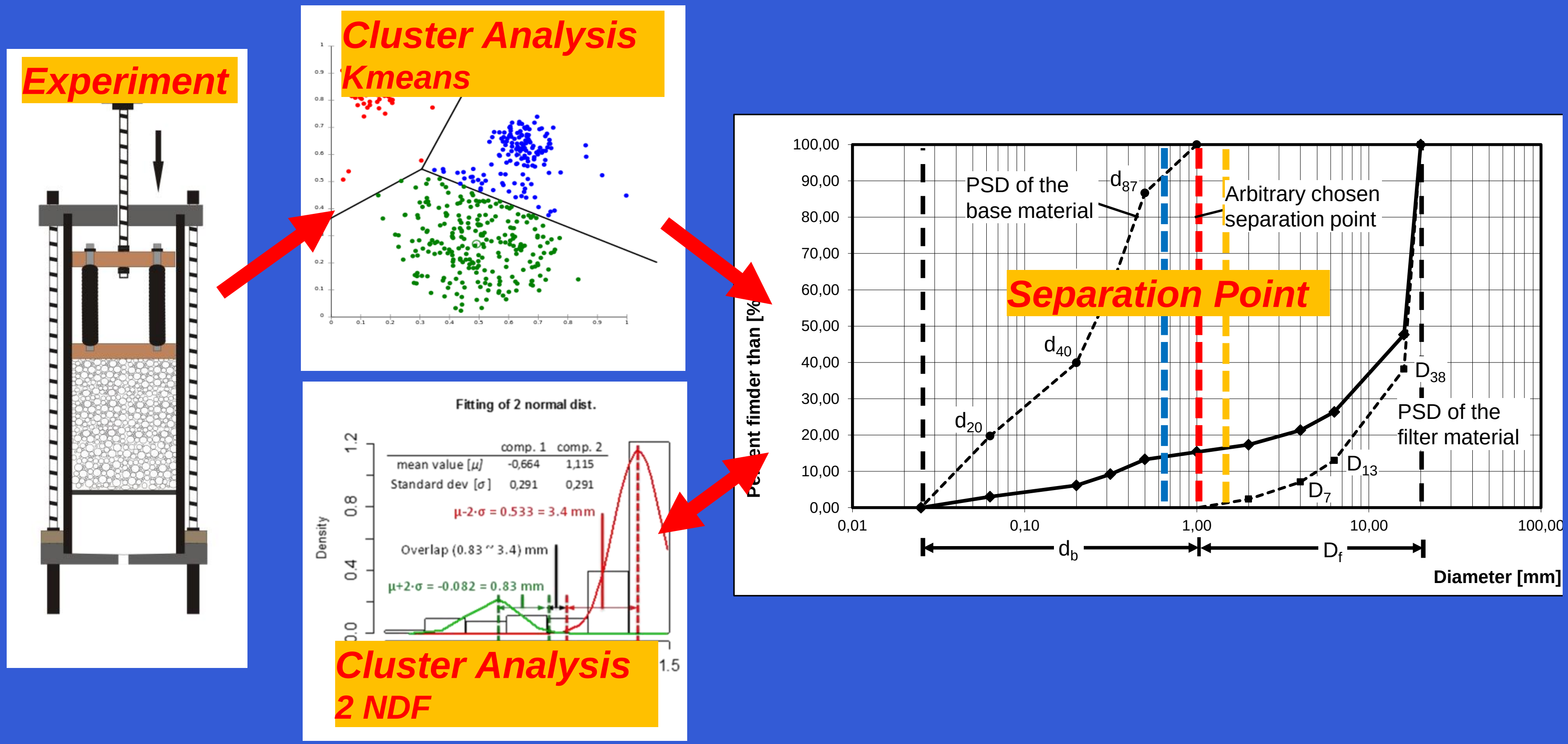
Cluster analysis of the data set (Porosity n and Relative Height h_r)

Cluster Analysis R-*Mixtools*



PDF of particle size distribution fitted with a parametric algorithm in R - Right: histogram of particles is clearly suggestive of a two-component mixture; Left: the fitted Gaussian components

Summary



1. The Results → number of sieves.
2. Minor differences in the shape of the PSD → changes of mobile particles
3. The clustering results of soil PDF using two normal distributions agree fairly well with the conducted test results.

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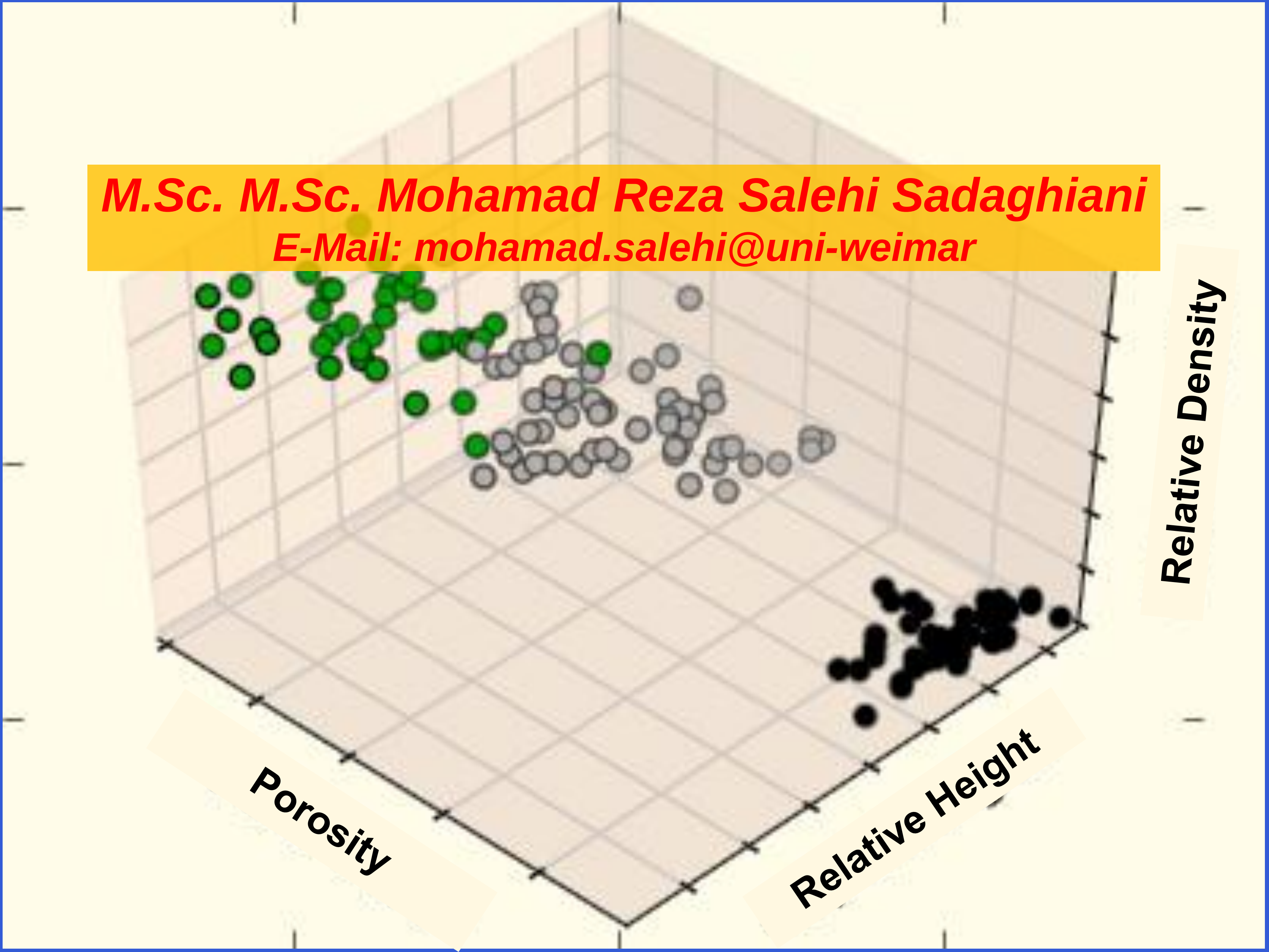

EXTRA

#	Class			Percent feiner than	Mass			Mass	
	d_i	d_{i+1}	$d_{i,mittel}$	R	m_i	$m_i/4$	$m_{i(1/4),cumulative}$	Percent	cumulative
	[m]	[mm]	[mm]	[%]	[g]	[g]	[g]	[%]	[%]
1	20,0	16,0	17,889	52,02	3255	813,75	1552,5	52,42	100,00
2	16,0	6,3	10,040	21,93	1326	331,5	738,8	21,35	47,58
3	5,0	5,0	5,000	5,04	315	78,75	407,3	5,07	26,23
4	3,0	3,0	3,000	4,01	251	62,75	328,5	4,04	21,16
5	1,3	1,0	1,140	2,00	125	31,25	265,8	2,01	17,12
6	0,75	0,5	0,612	2,00	125	31,25	234,5	2,01	15,10
7	0,5	0,250	0,354	7,01	439	109,75	203,3	7,07	13,09
8	0,250	0,150	0,194	5,99	374	93,5	93,5	6,02	6,02
9	0,150	0,100	0,122						0,00
10									
				100,00	6210			100,00	

#	Height		Mass of Water	Volume		Porosity		Density	Relative Height	
	h_1	h_2	m_w	V_w	V_{total}	V_w/V_{total}	$(V_w/V_{total})*100$	$m_{i,cumulative}/V_{tc}$	h_2/h_{total}	$(h_2/h_{total})*100$
	[cm]	[cm]	[g]	[cm³]	[cm³]	[-]	[-]	[g/cm³]	[%]	[%]
1	15,2	15,2	1061	1061	2306,55	0,460	45,999	1,41	0,694	69,41
2	19,7	19,7	1104	1104	2989,41	0,369	36,930	1,53	0,900	89,95
3	20,55	20,5	1018	1018	3110,81	0,327	32,725	1,57	0,936	93,61
4	21,7	21,6	1066	1066	3277,73	0,325	32,523	1,57	0,986	98,63
5	21,5	21,5	957	957	3262,56	0,293	29,333	1,62	0,982	98,17
6	21,9	21,9	1009	1009	3323,25	0,304	30,362	1,62	1,000	100,00
7	20,9	20,9	745	745	3171,51	0,235	23,490	1,84	0,954	95,43
8	22,1	21,4	532	532	3247,38	0,164	16,382	1,91	0,977	97,72
9										
10										