Fingerprinting Marbles by Combining Neutron Diffraction and Imaging

Università di Palermo

Oak Ridge, 10.25.06

Thank you

Università di Palermo	V. Benfante, D. I. Donato, F. Lo Celso, I. Ruffo
Università di Modena e Reggio Emilia	C. Gorgoni, P. Pallante
HMI-BENSC (DE)	A. Hilger, N. Kardijlov, M. Strobl, W. Treimer
NIST (USA)	J. Barker, P. Butler
ISIS (UK)	W. Kockelmann

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Presentation Plan

ND - SANS - USANS

White Marbles
and
Polychromic Marbles

Neutron Tomography and Radiography

Polychromic Marbles

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Why Marble?

Marble is one of the most common stone used for monuments, statues and other objects of archaeological or cultural heritage interest.

The provenance of stone objects is of key importance to archaeology.

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Why
ND, SANS and USANS?

Why
Neutron Imaging?

Why
Neutrons?

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How did marbles form?

Foraminiphera

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Metamorphism

Changes in Rock Composition or Texture due to Heat, Pressure and Action of Fluids

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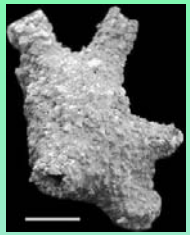
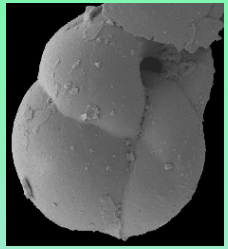
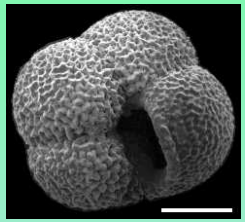
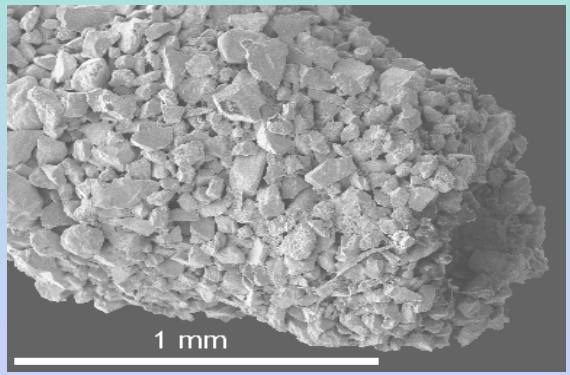
It happened long ago ....









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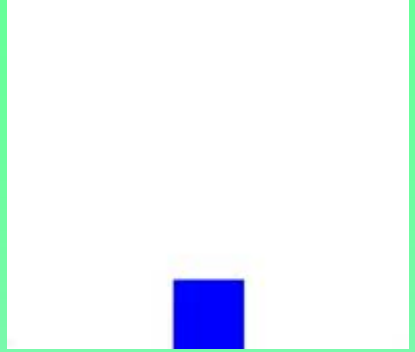
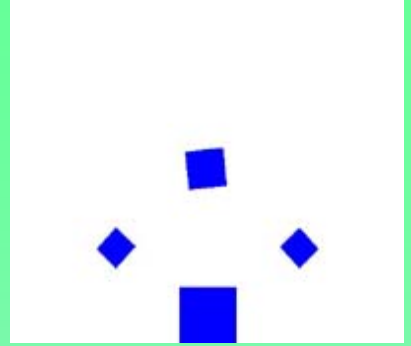
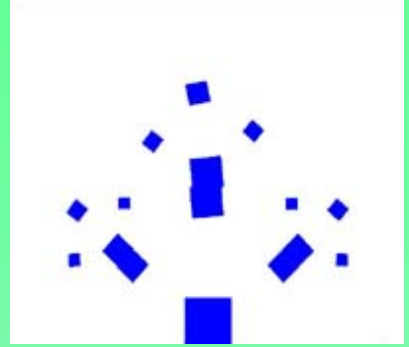





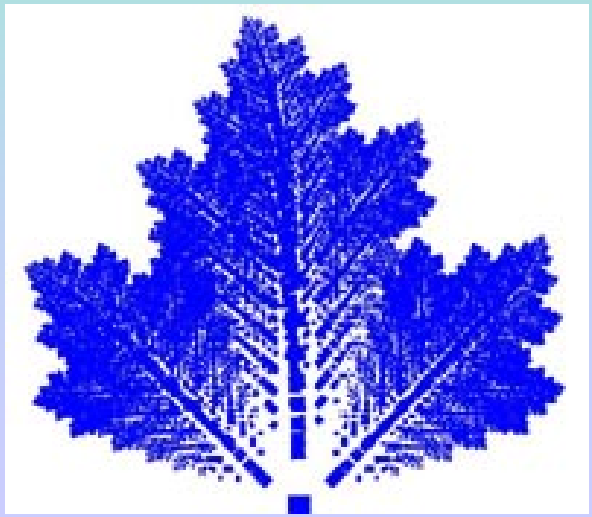


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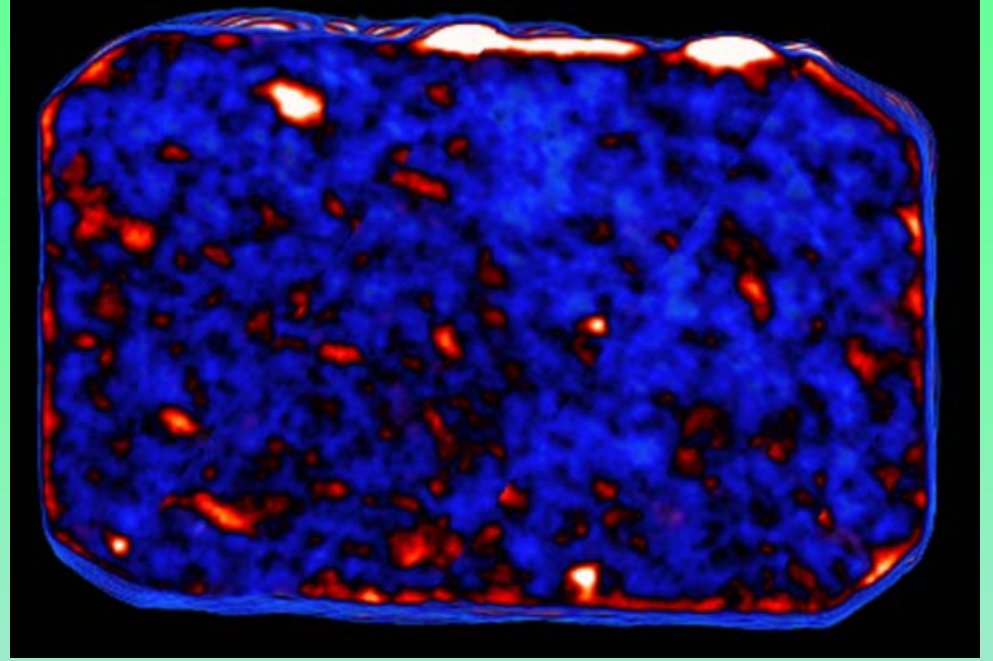

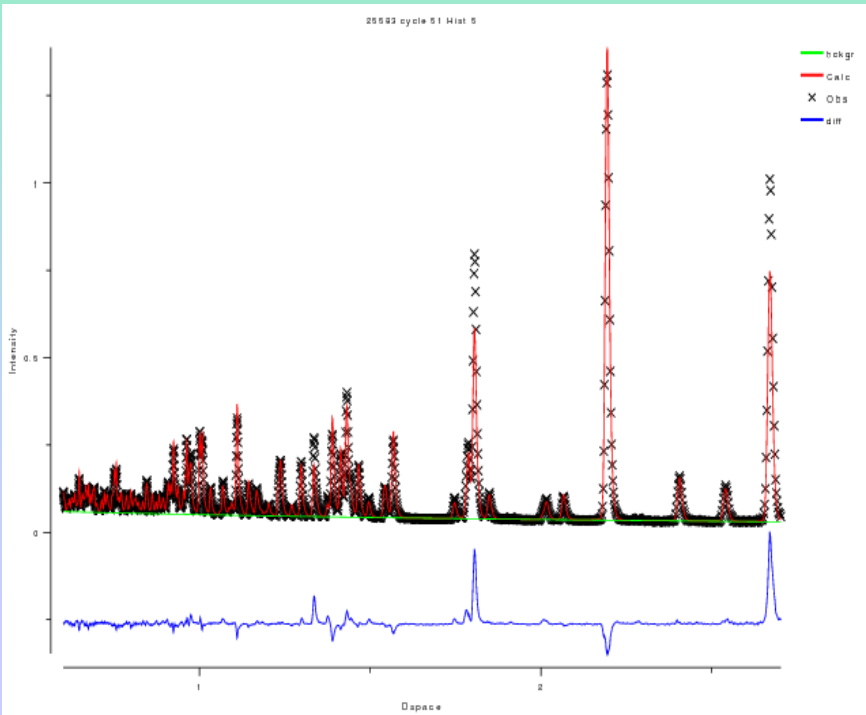

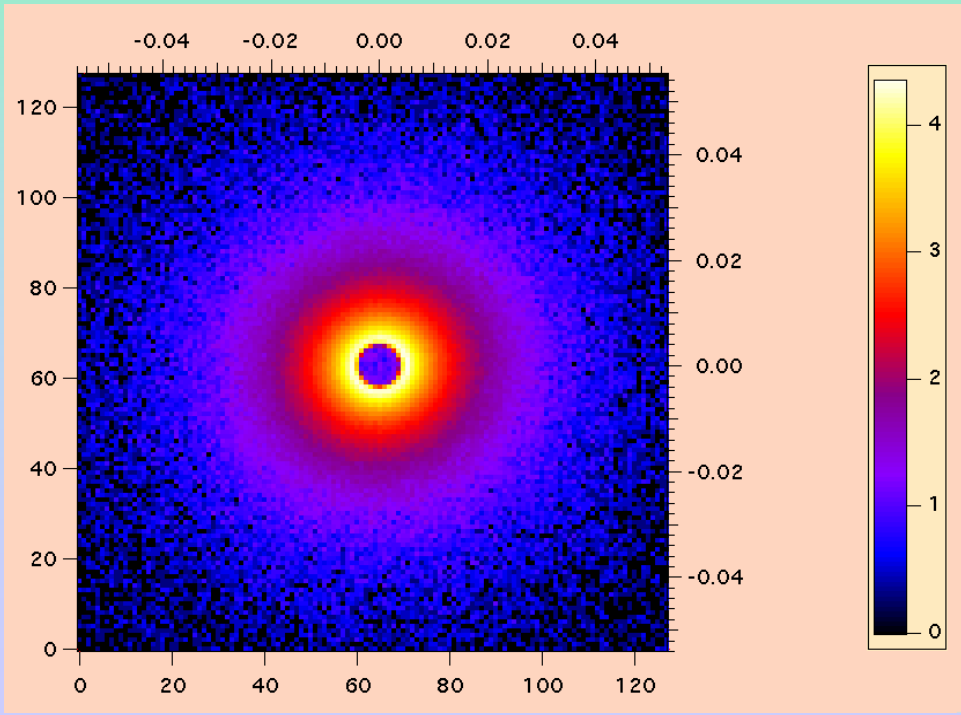

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Let's now see how neutrons can help us

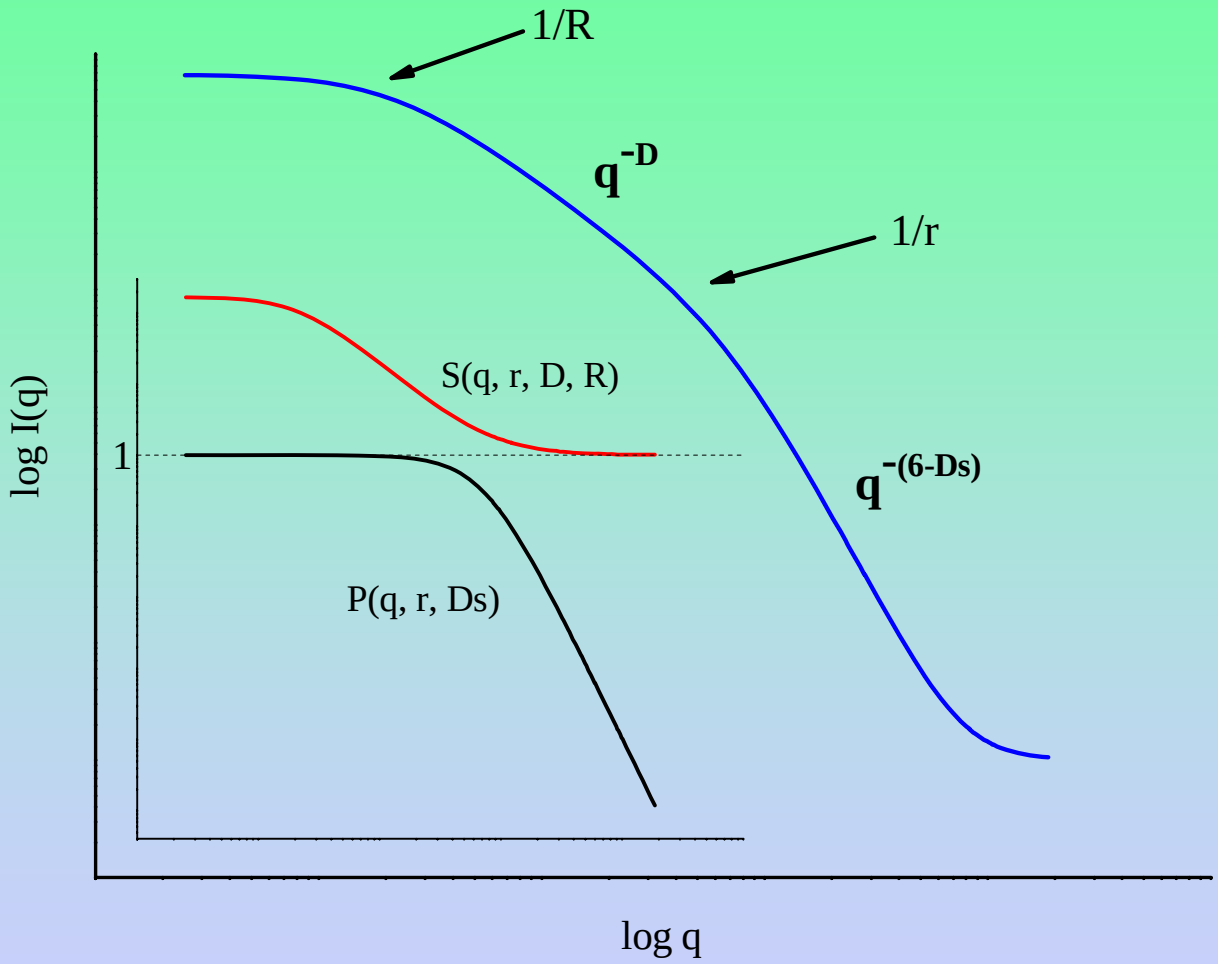
$$I(q) \propto P(q,r,Ds)\cdot S(q,r,D,R)$$

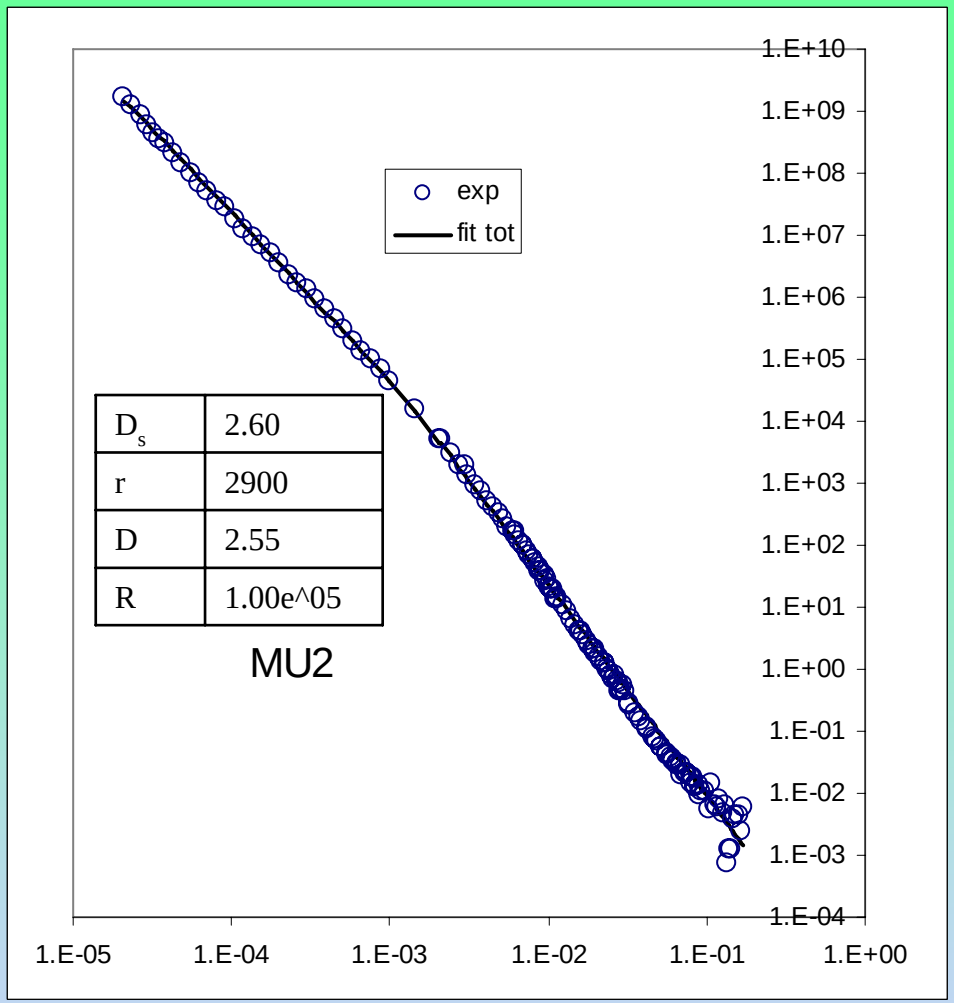
$$P(q,r,Ds) = \left(1+\frac{\sqrt{2}}{3}q^2r^2\right)^{\frac{Ds-6}{2}}$$

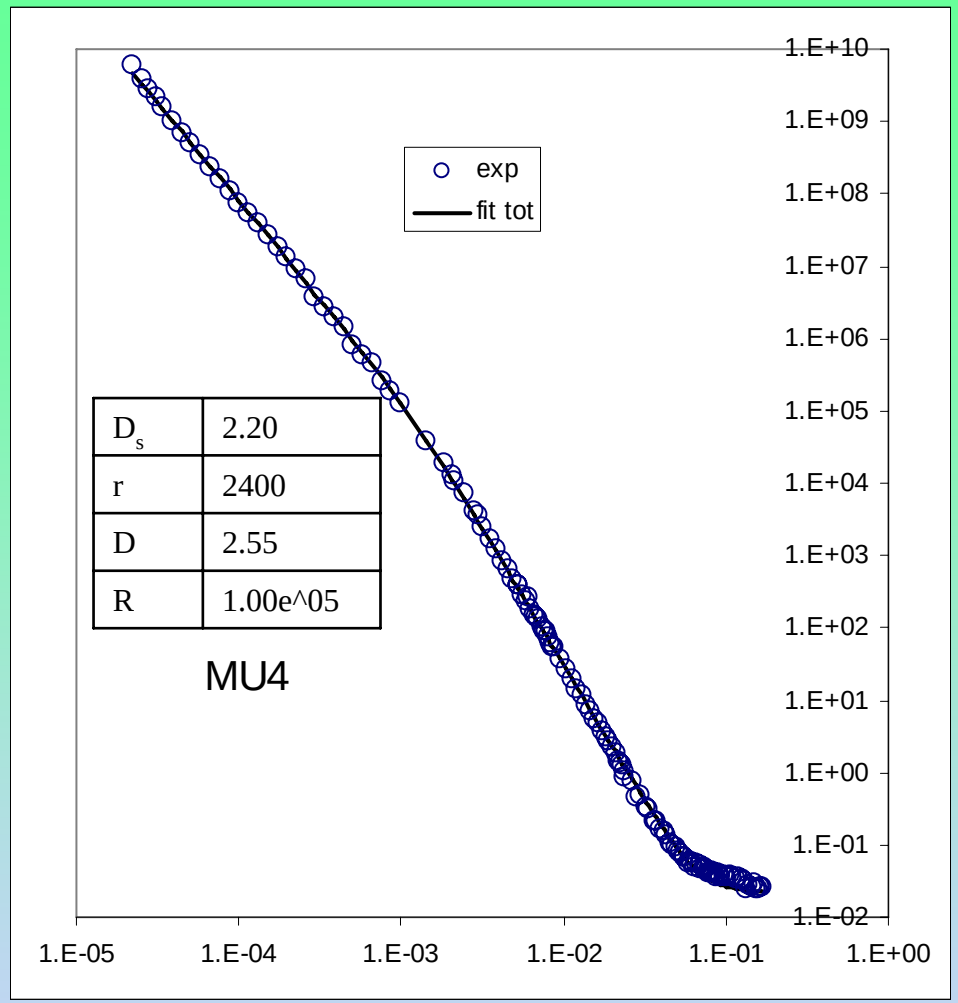
$$S(q,r,D,R) = 1+\frac{D\Gamma(D-1)}{qr^D}\left(1+\frac{1}{qR^2}\right)^{\frac{1-D}{2}}\sin\left[(D-1)\arctan(qR)\right]$$

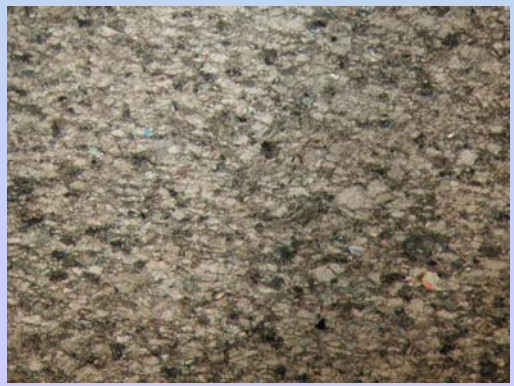
A. Emmerling et al., J. of Non Cryst. Sol. 185, 240 (1994)

J. Teixeira, J. App. Cryst., 21, 781 (1988)


1/R
q-D
1/r
S(q, r, D, R)
1
q-(6-Ds)
P(q, r, Ds)
log I(q)
log q







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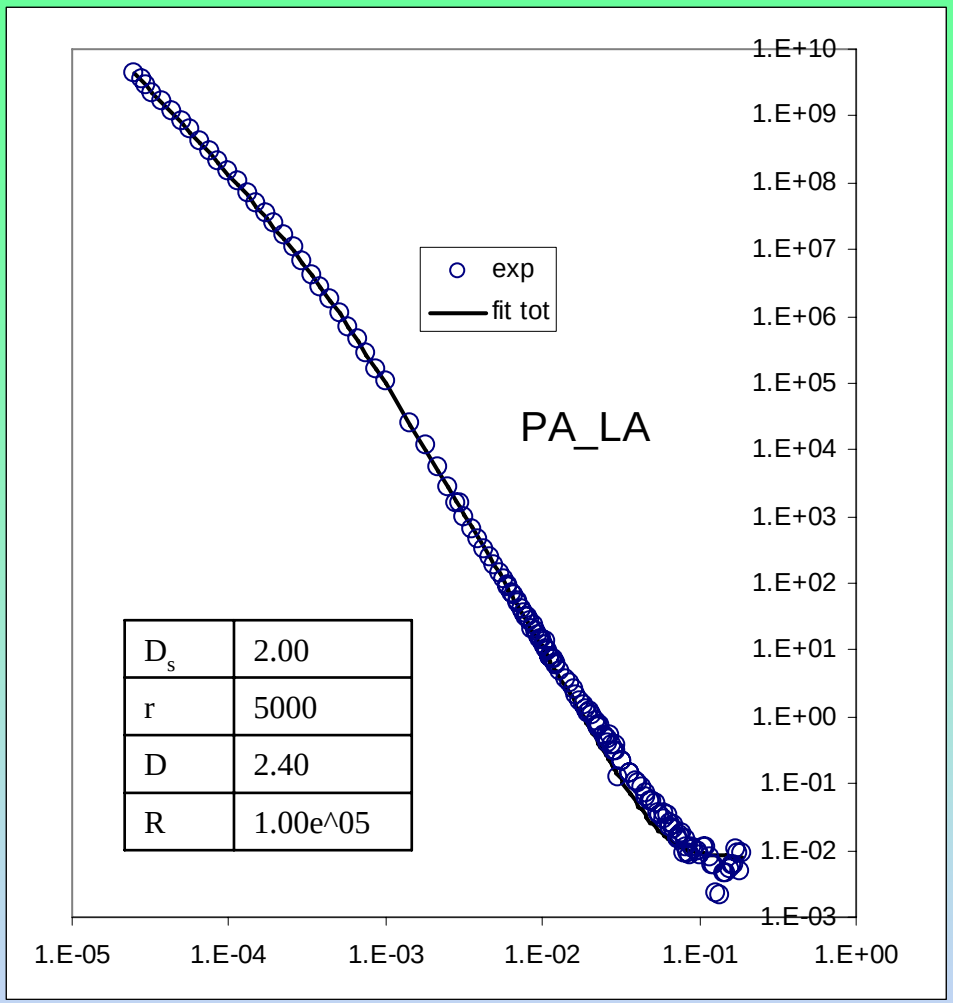
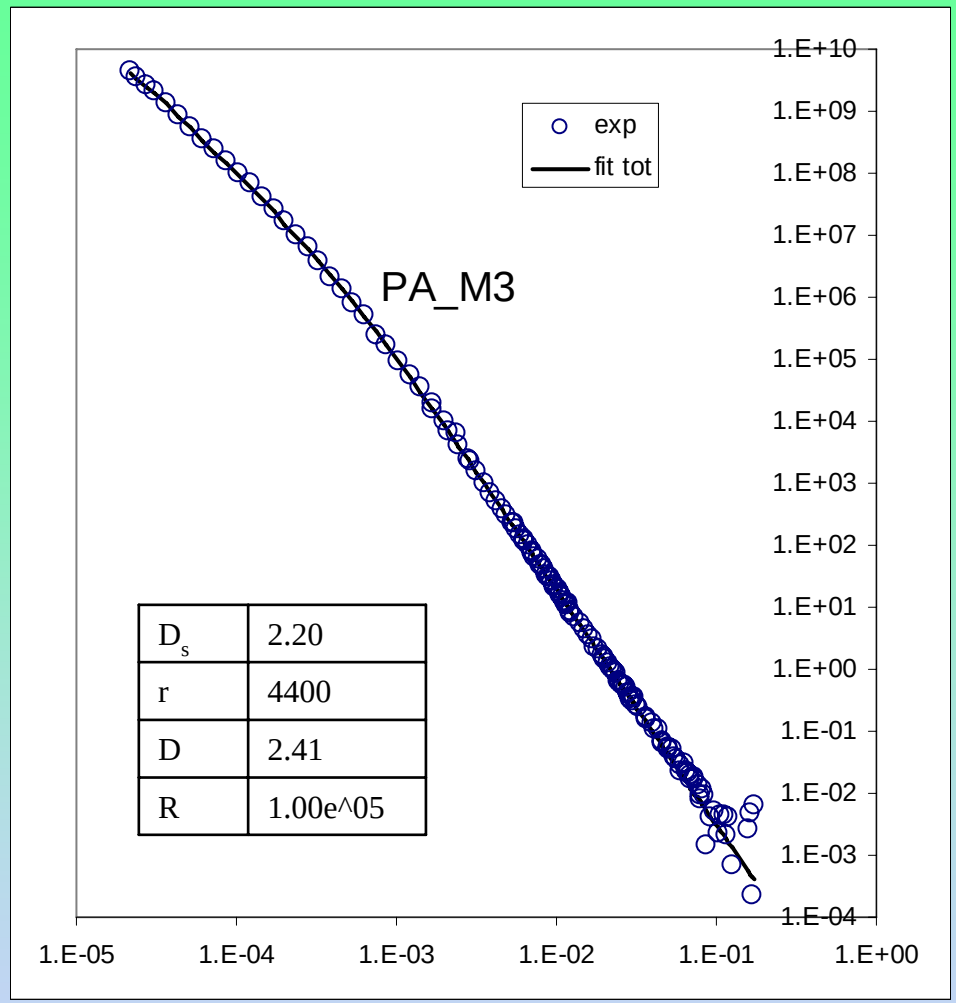
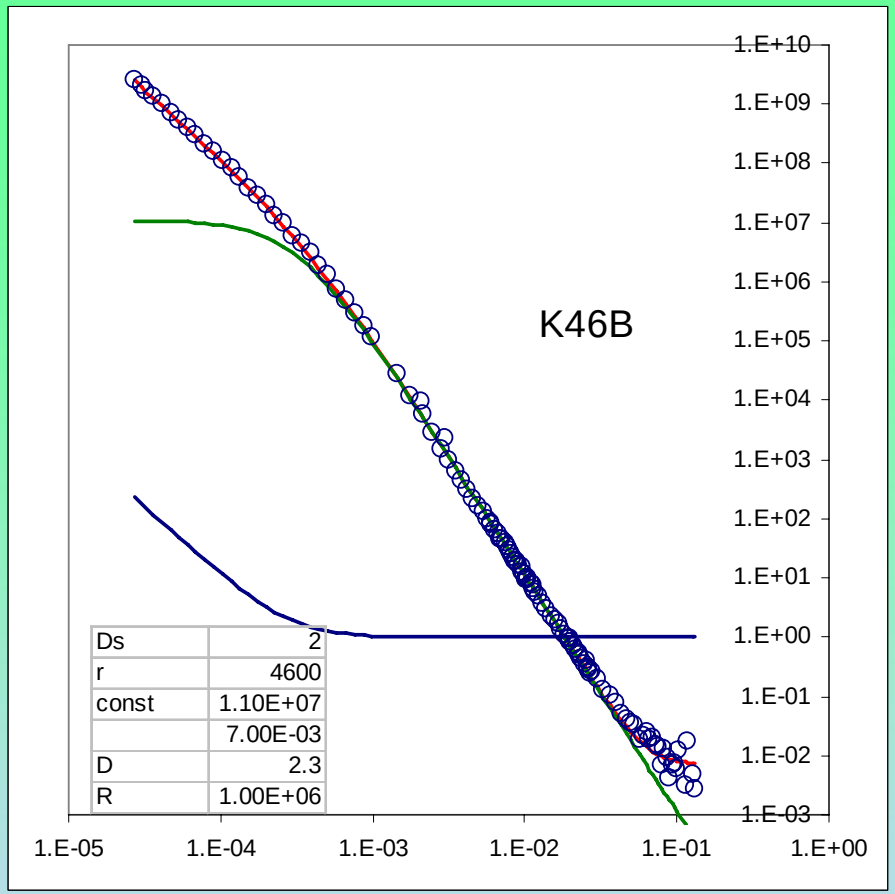
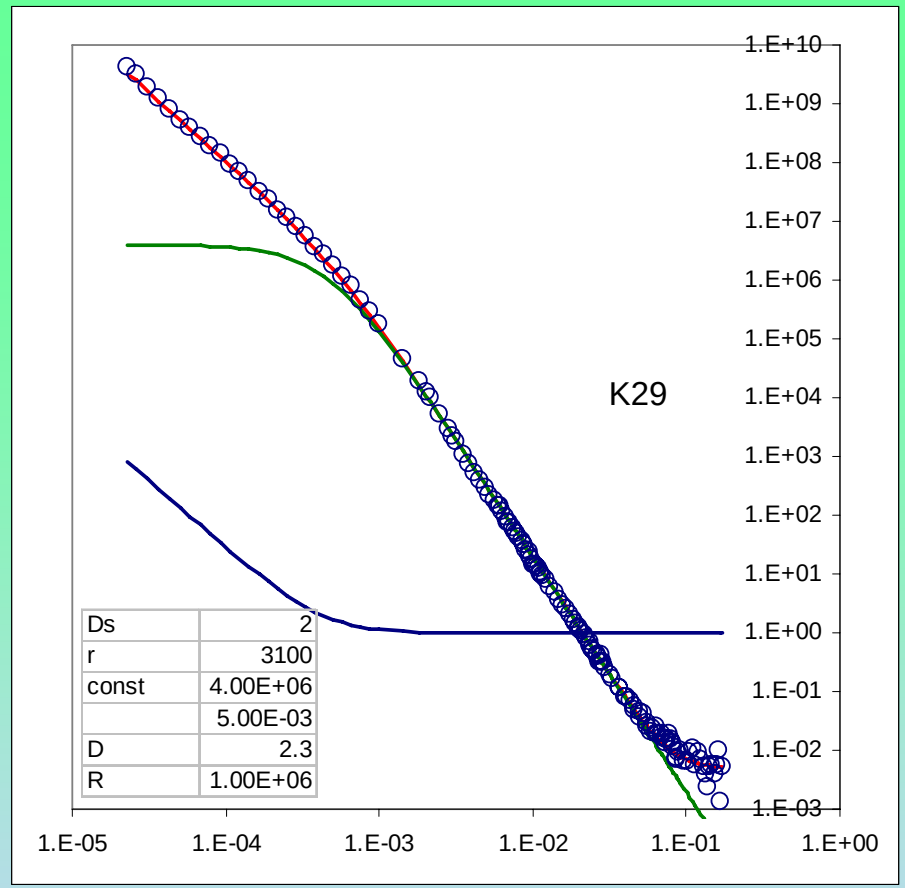
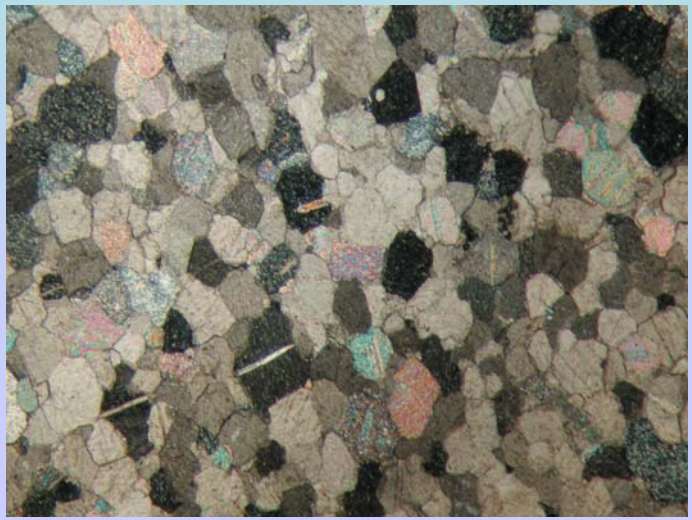

exp
fit tot
PA_LA
D_s 2.00
r 5000
D 2.40
R 1.00e^05
1.E+10
1.E+09
1.E+08
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00


exp
fit tot
PA_M3
D_s 2.20
r 4400
D 2.41
R 1.00e^05
1.E+10
1.E+09
1.E+08
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00







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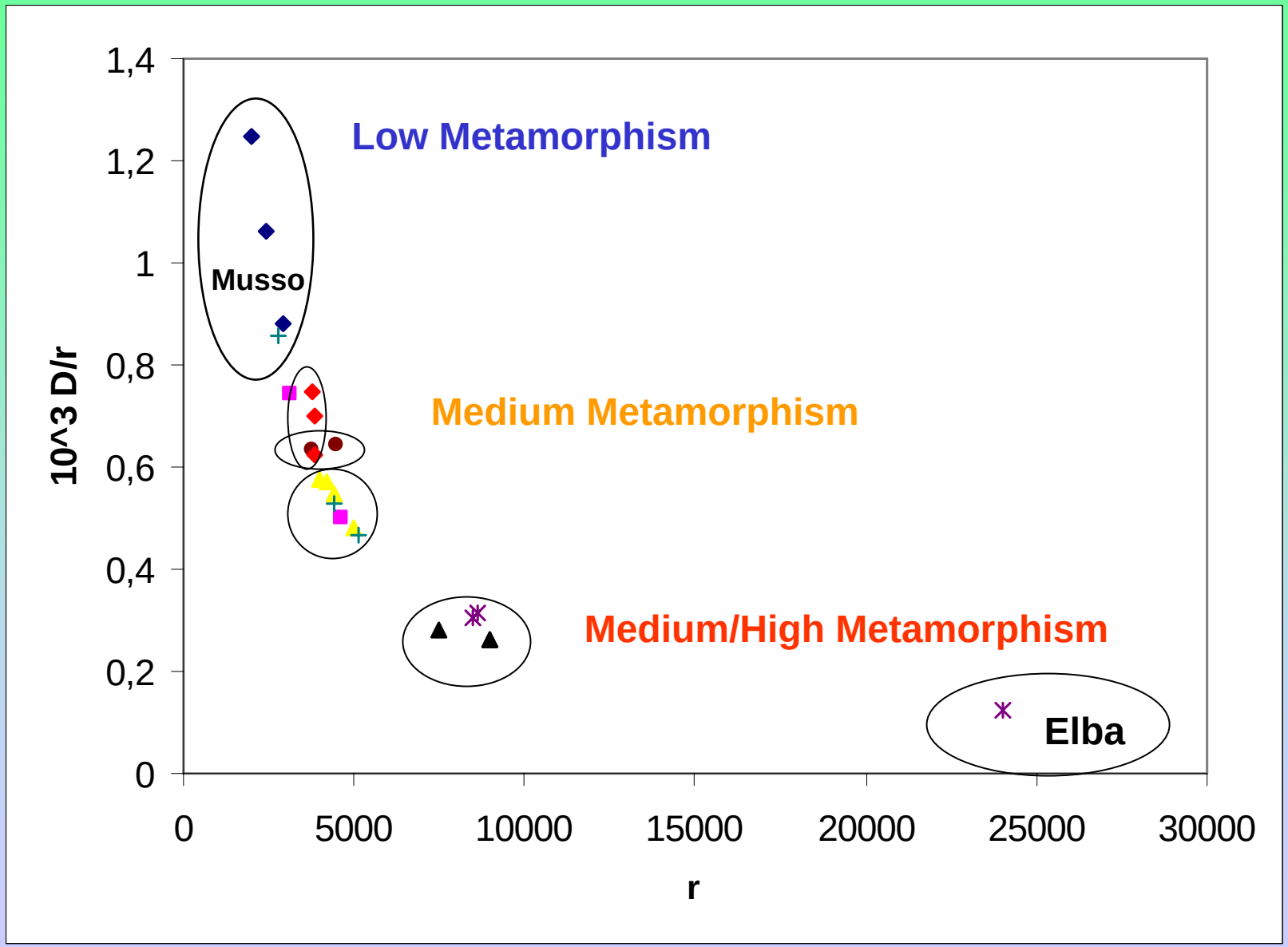
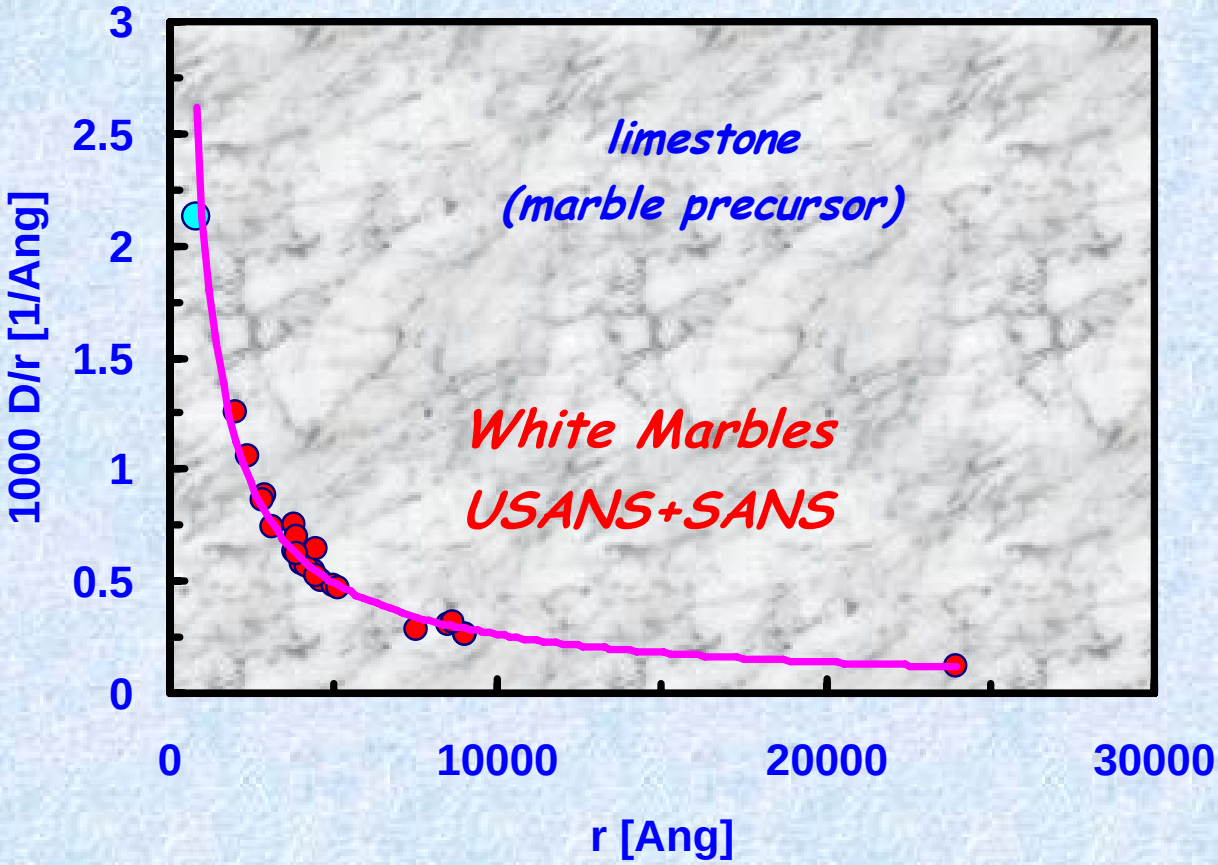
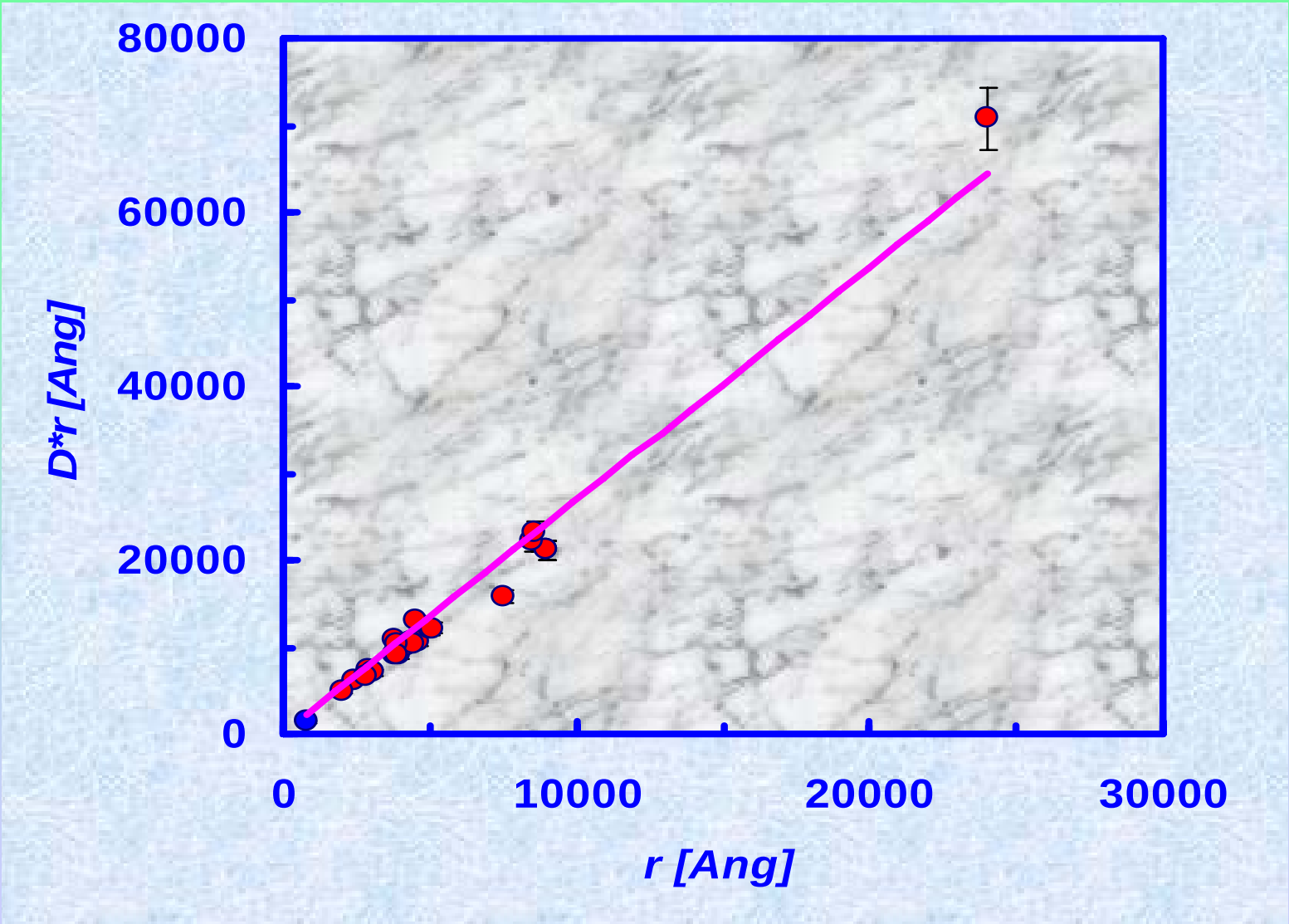
And now how do we "use" The fit parameters?


Low Metamorphism
Musso
Medium Metamorphism
Medium/High Metamorphism
Elba
10^3 D/r
r
1,4
1,2
1
0,8
0,6
0,4
0,2
0
0
5000
10000
15000
20000
25000
30000


limestone
(marble precursor)
White Marbles
USANS+SANS
1000 D/r [1/Ang]
r [Ang]
0
0.5
1
1.5
2
2.5
3
0
10000
20000
30000



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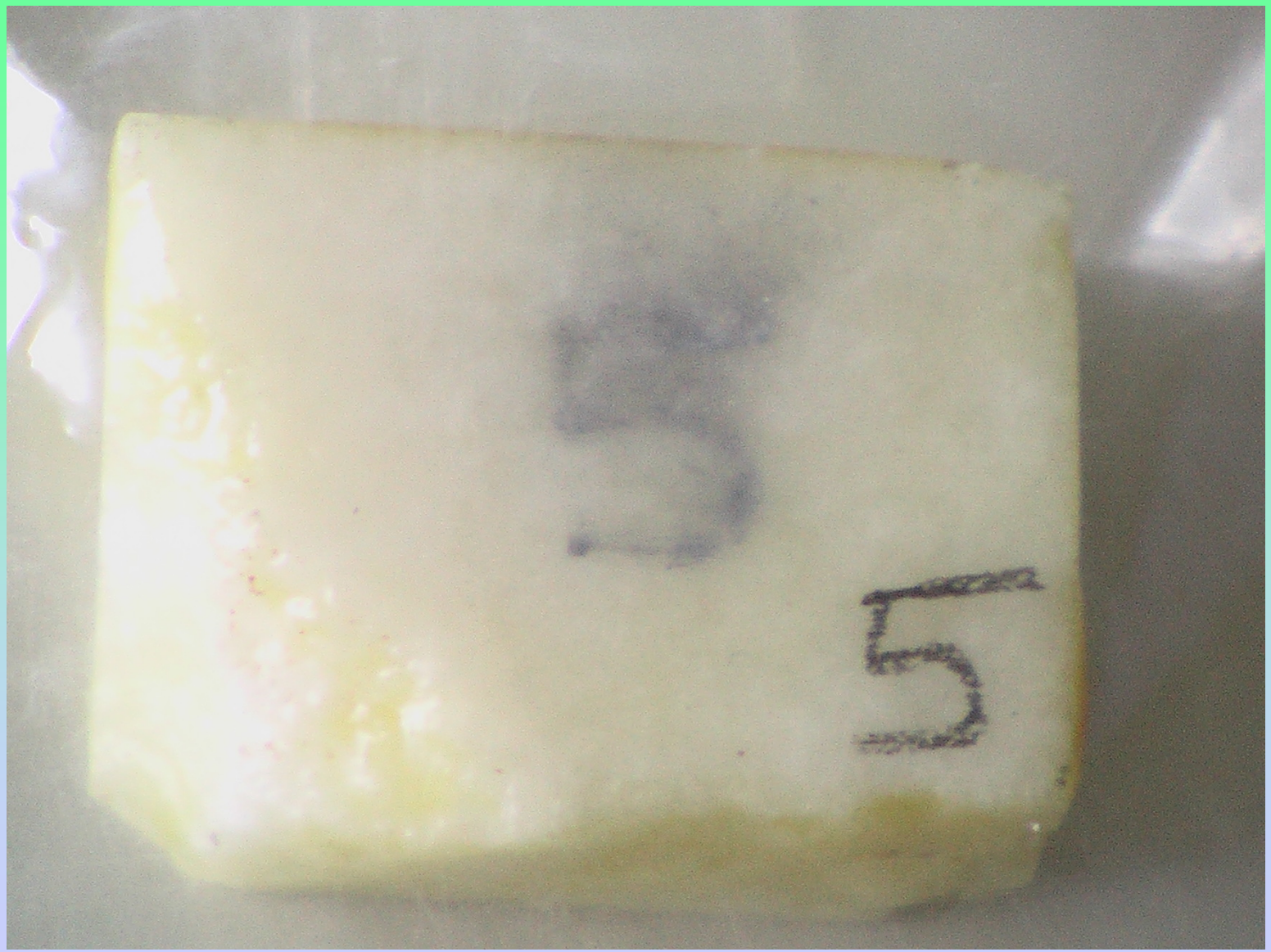

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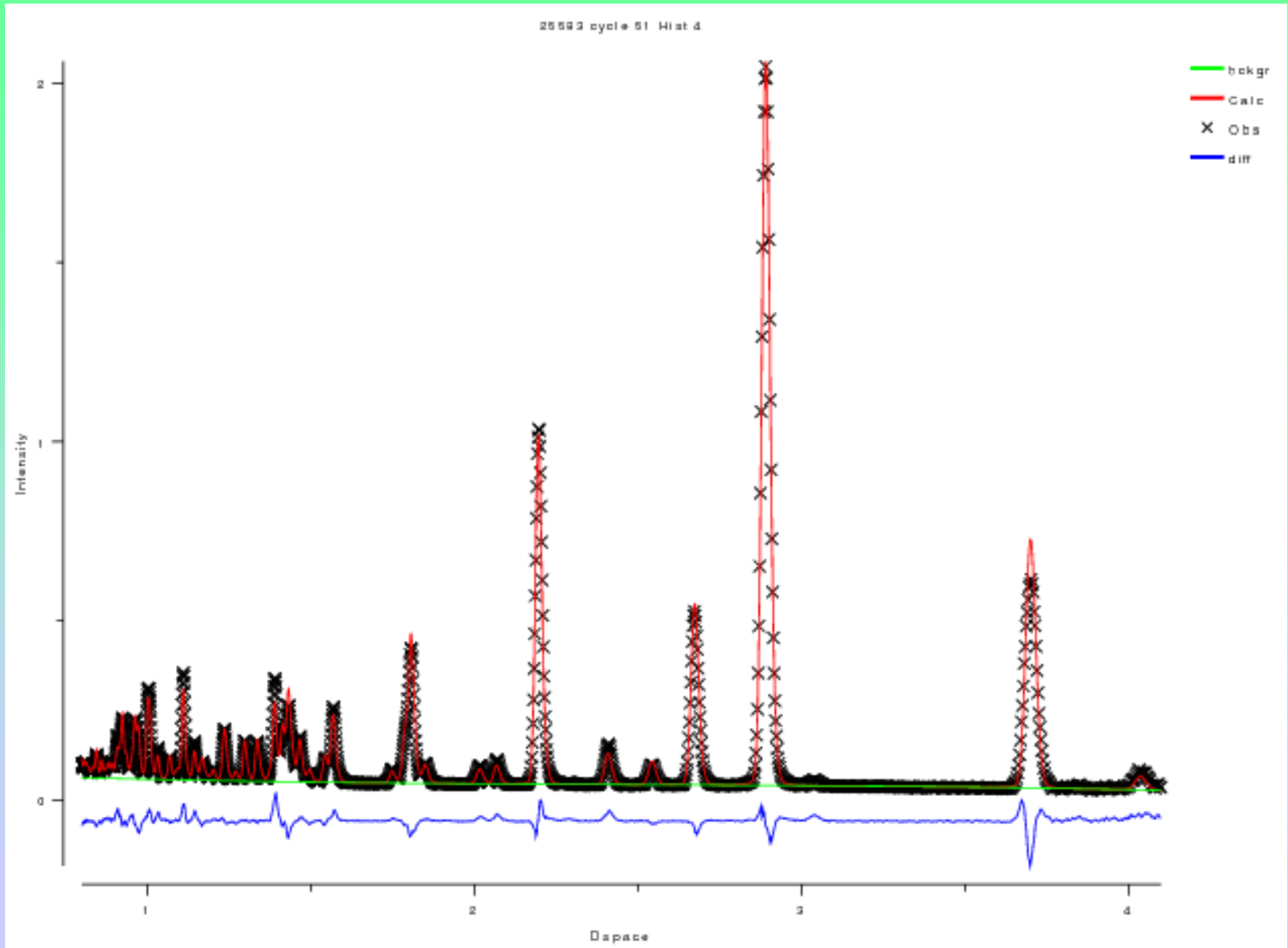

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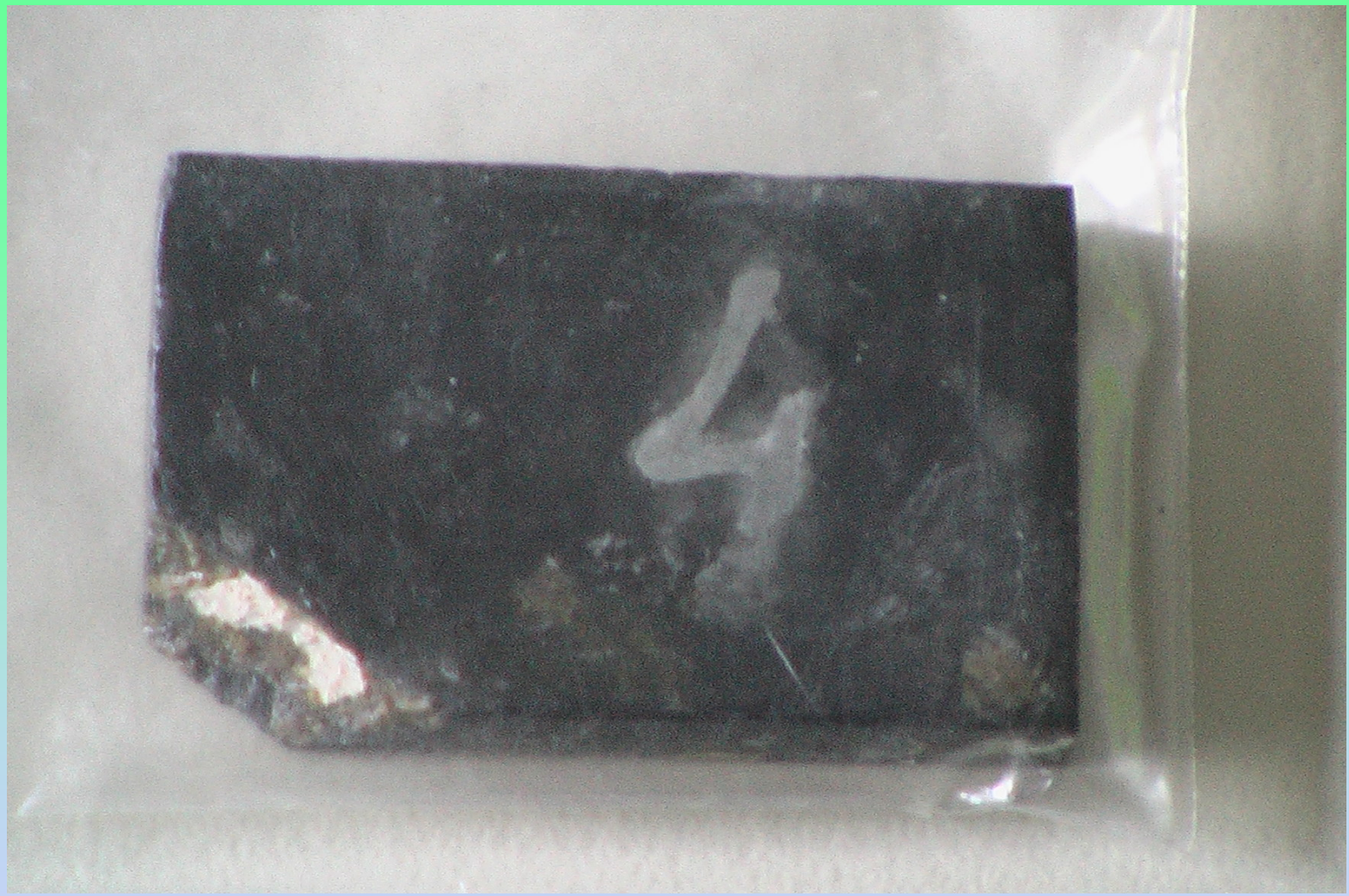

Component	Wt %
Calcite	15.8
Quartz	3.279
Muscovite/Illite	80.961

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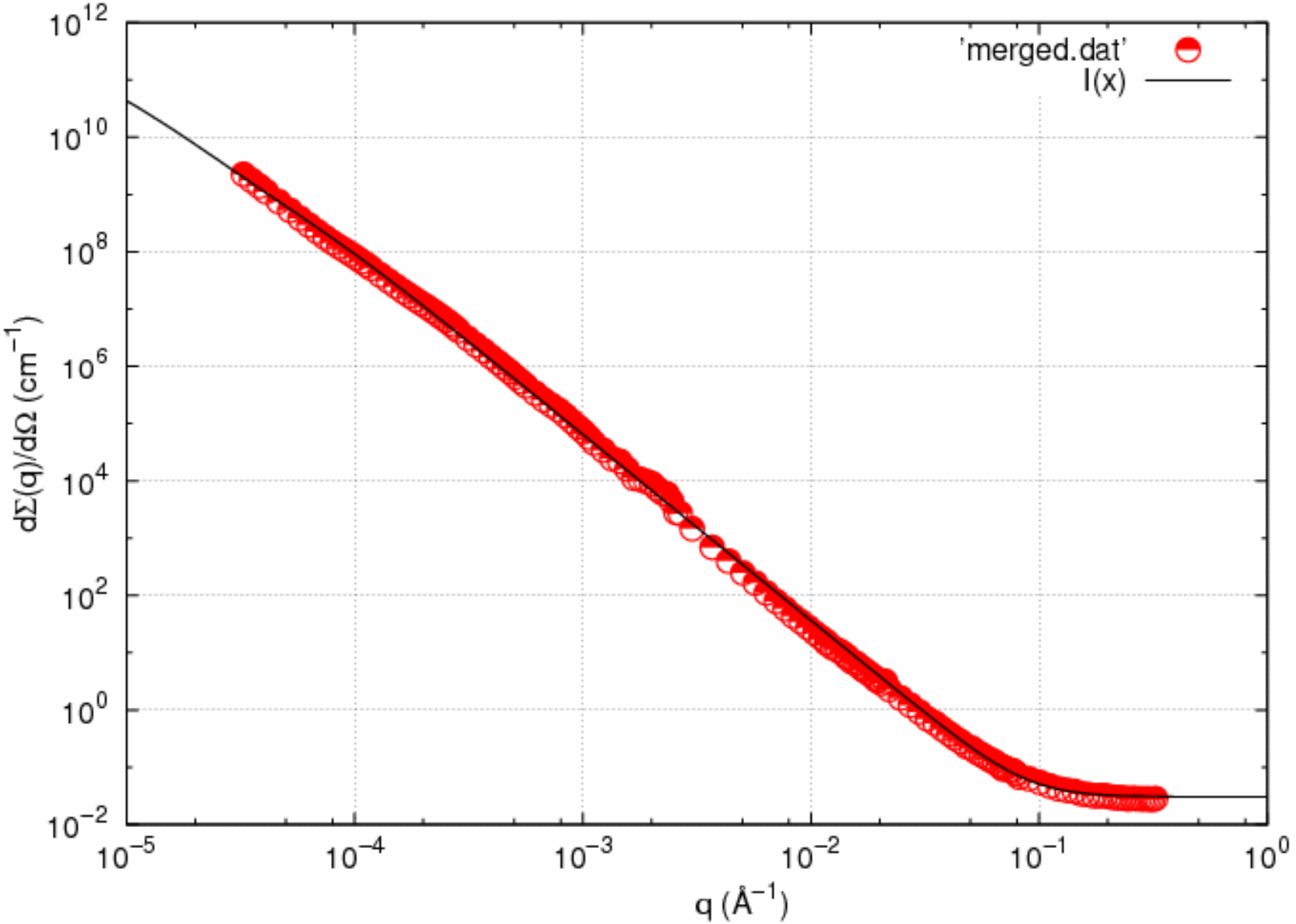

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Component	Wt %
Quartz	1.463
Plagioclase	83.004
Orthoclase	15.534

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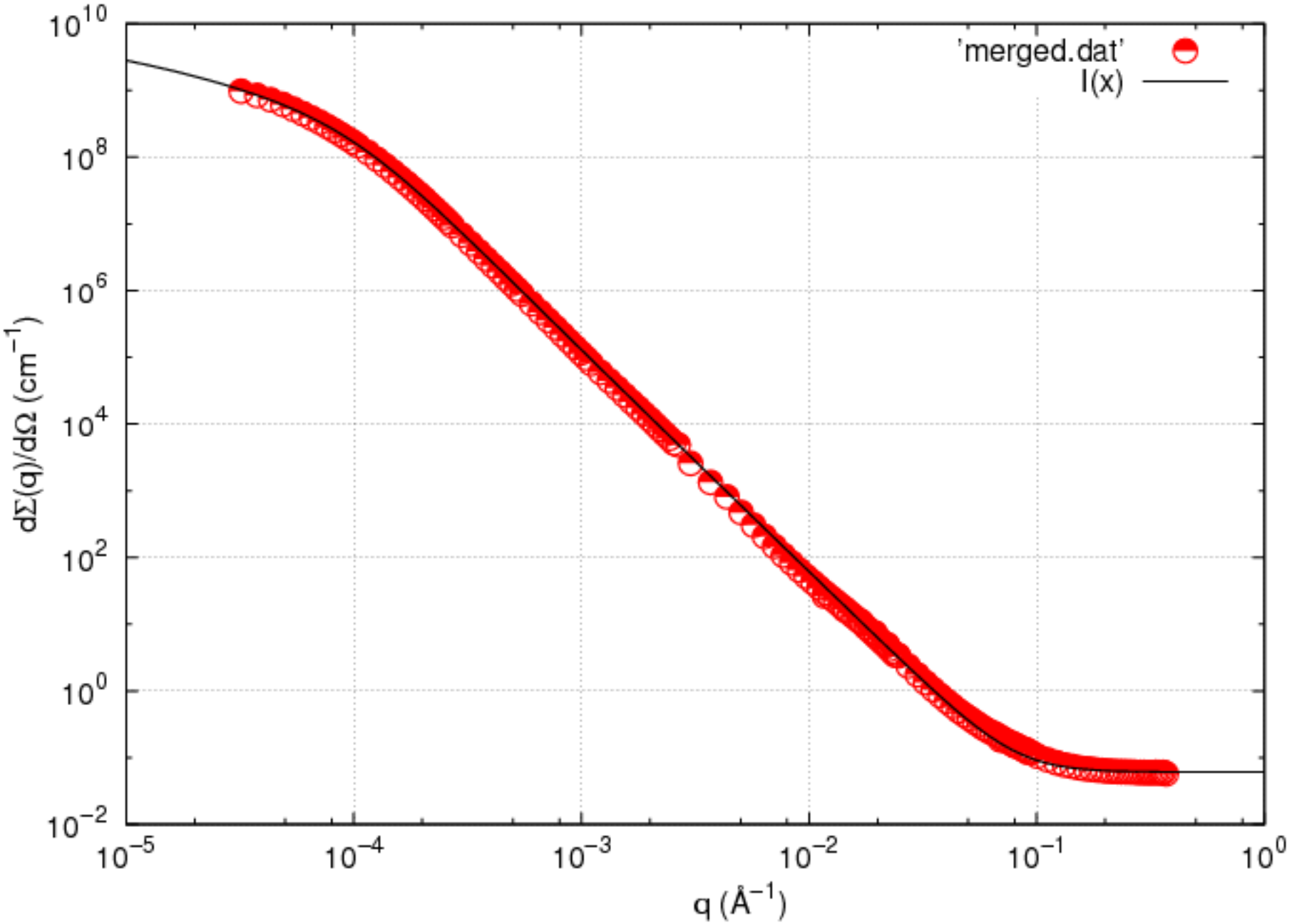
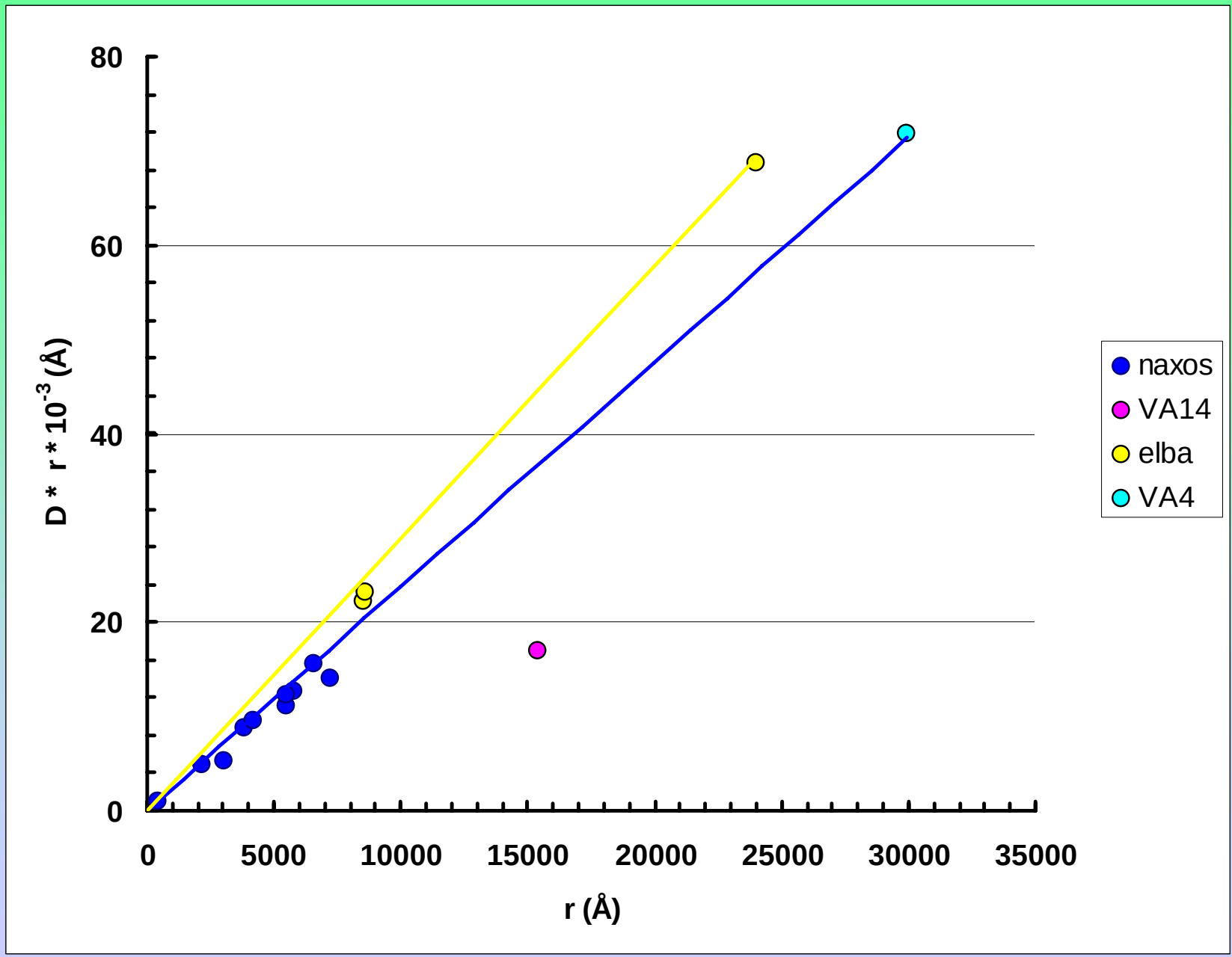

'merged.dat'
I(x)
dΣ(q)/dΩ (cm^{-1})
q (Å^{-1})
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
10^{0}
10^{-2}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}



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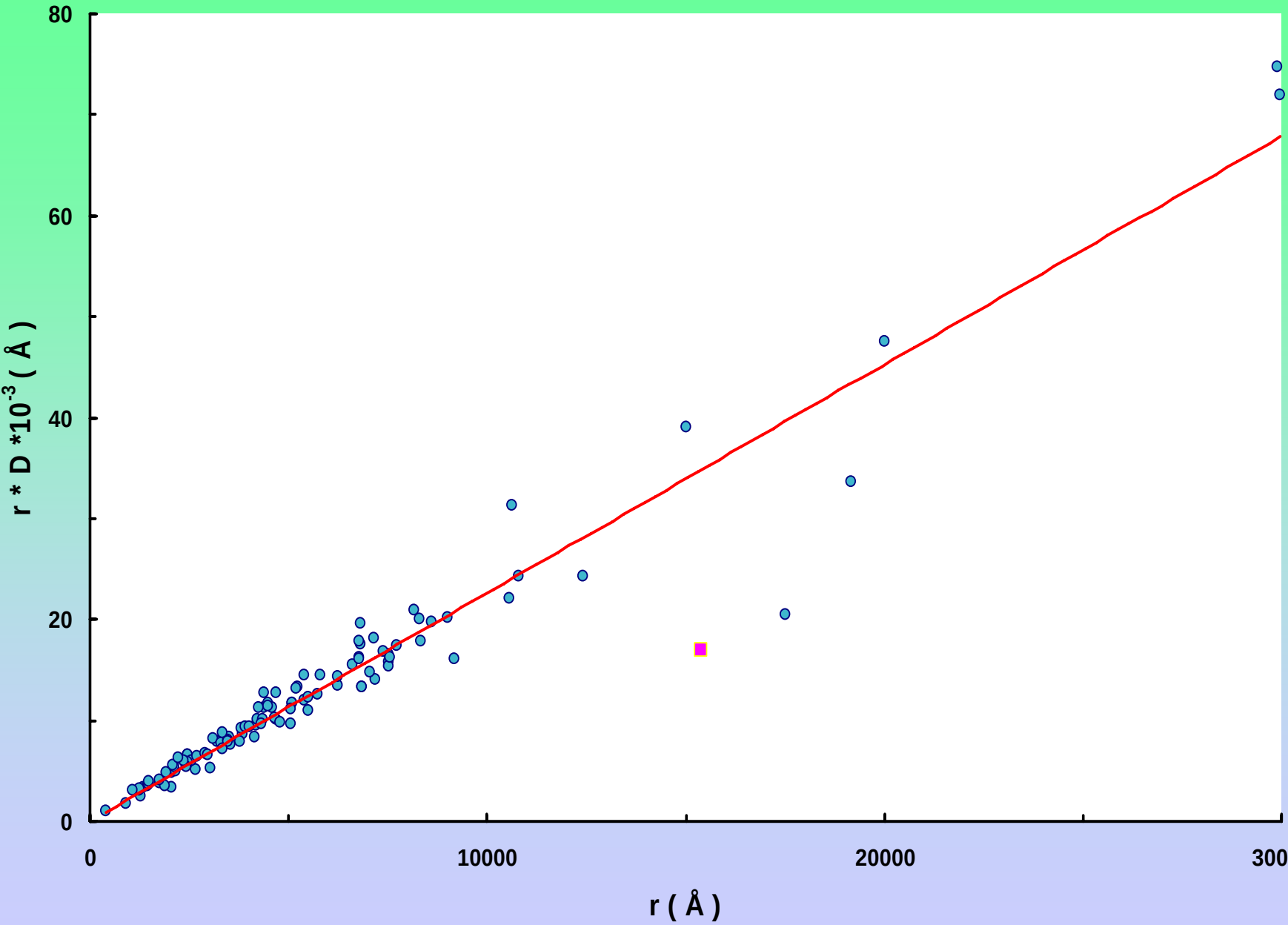

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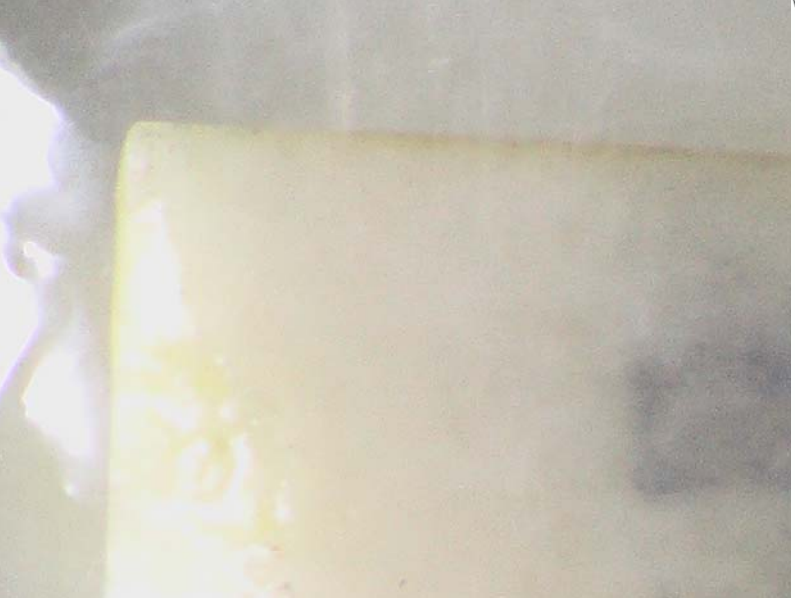
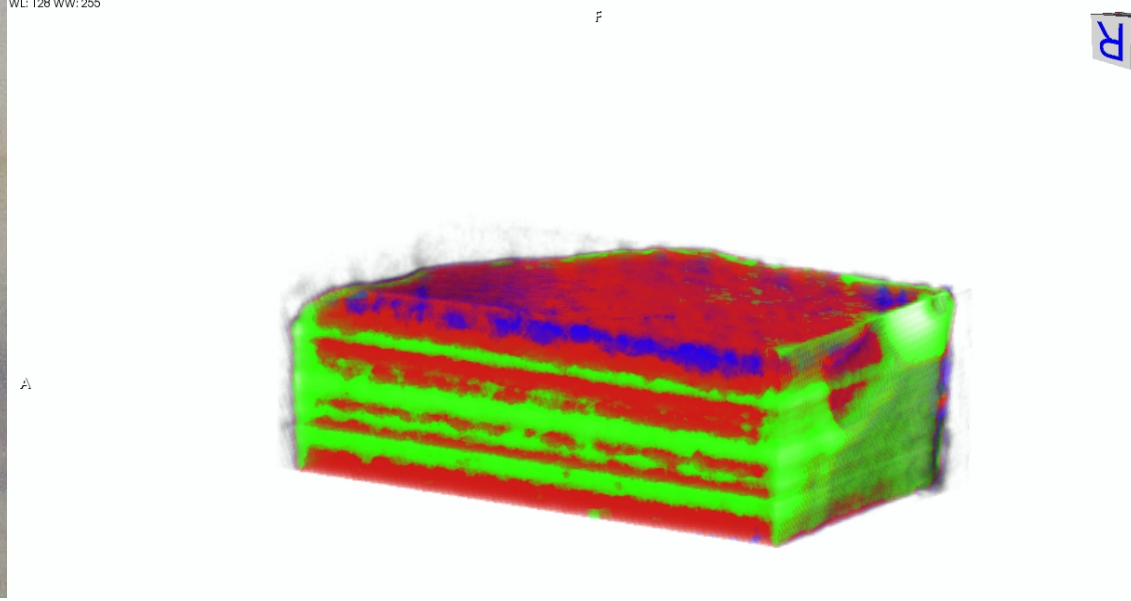
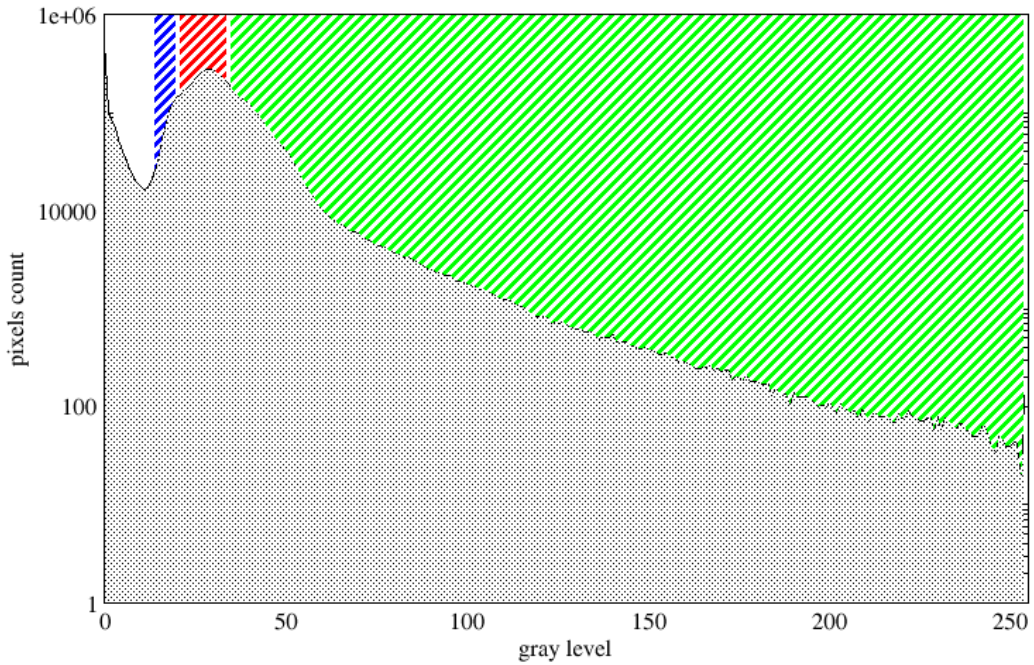



WL: 128 WW: 255
F
A
R


1e+06
10000
100
1
pixels count
0
50
100
150
200
250
gray level


H
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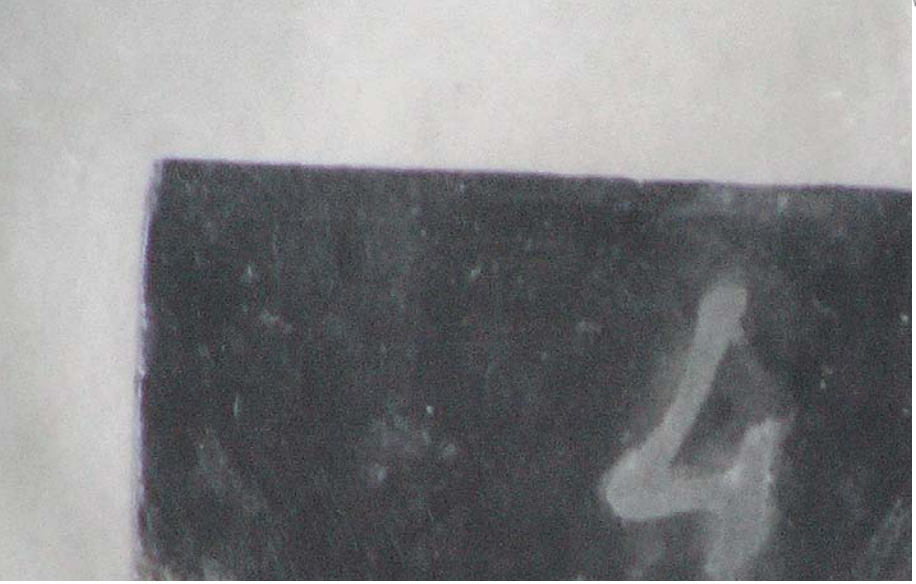

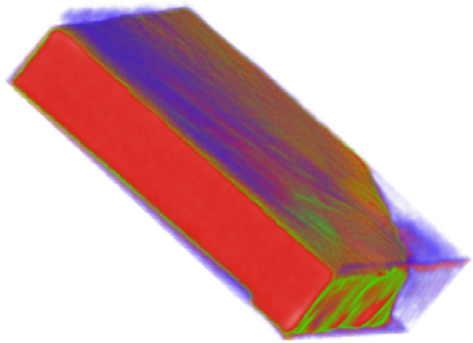

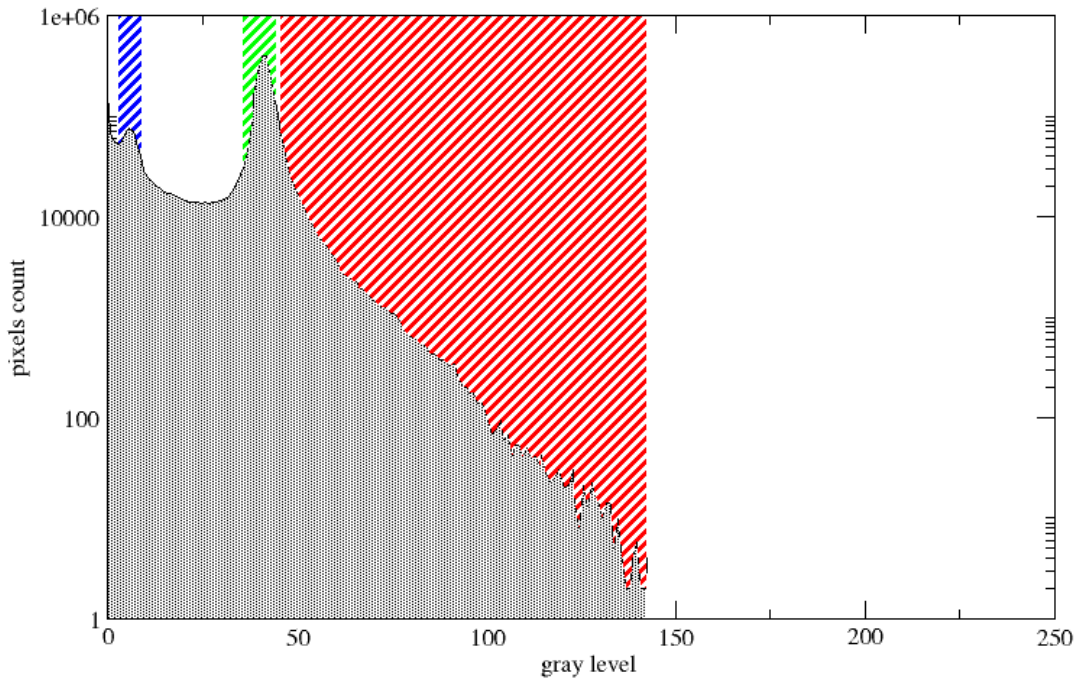
1e+06
10000
100
1
pixels count
0
50
100
150
200
250
gray level


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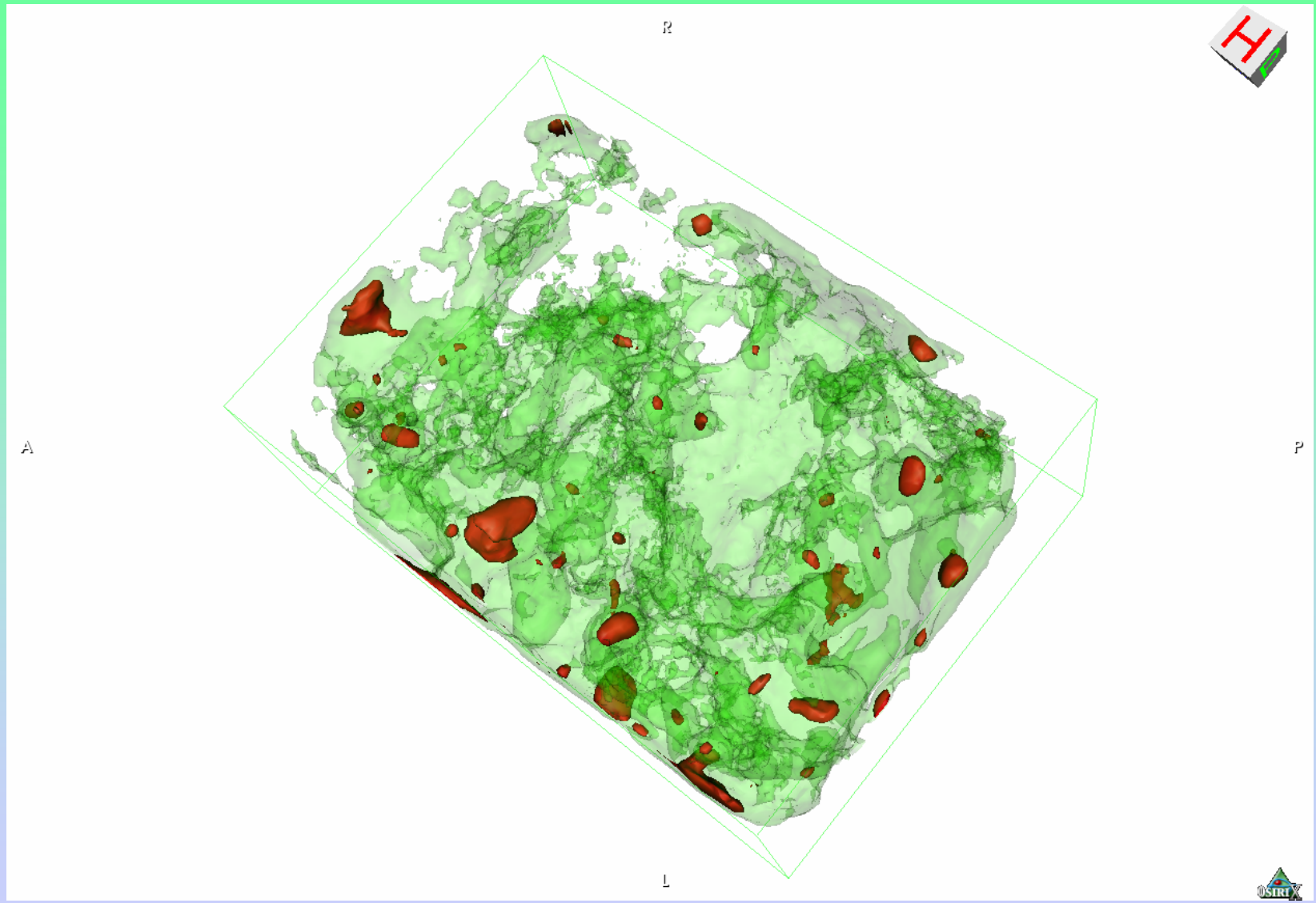

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Thank you so much!

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Major Metamorphic Rock Types

Temp C	Coal	Limestone	Sandstone	Basalt	Shale	Index Minerals
	Lignite Bituminous					
	Anthracite					
300	Graphite	**Marble**			Slate	**Chlorite**
				Greenstone		
			Quartzite		Phyllite	**Biotite**
500		**Marble**			Schist	**Garnet**
				Amphibolite		**Staurolite**
600		**Marble**			Gneiss	**Kyanite**
						Sillimanite
700		**Marble**				**Melting Begins**

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