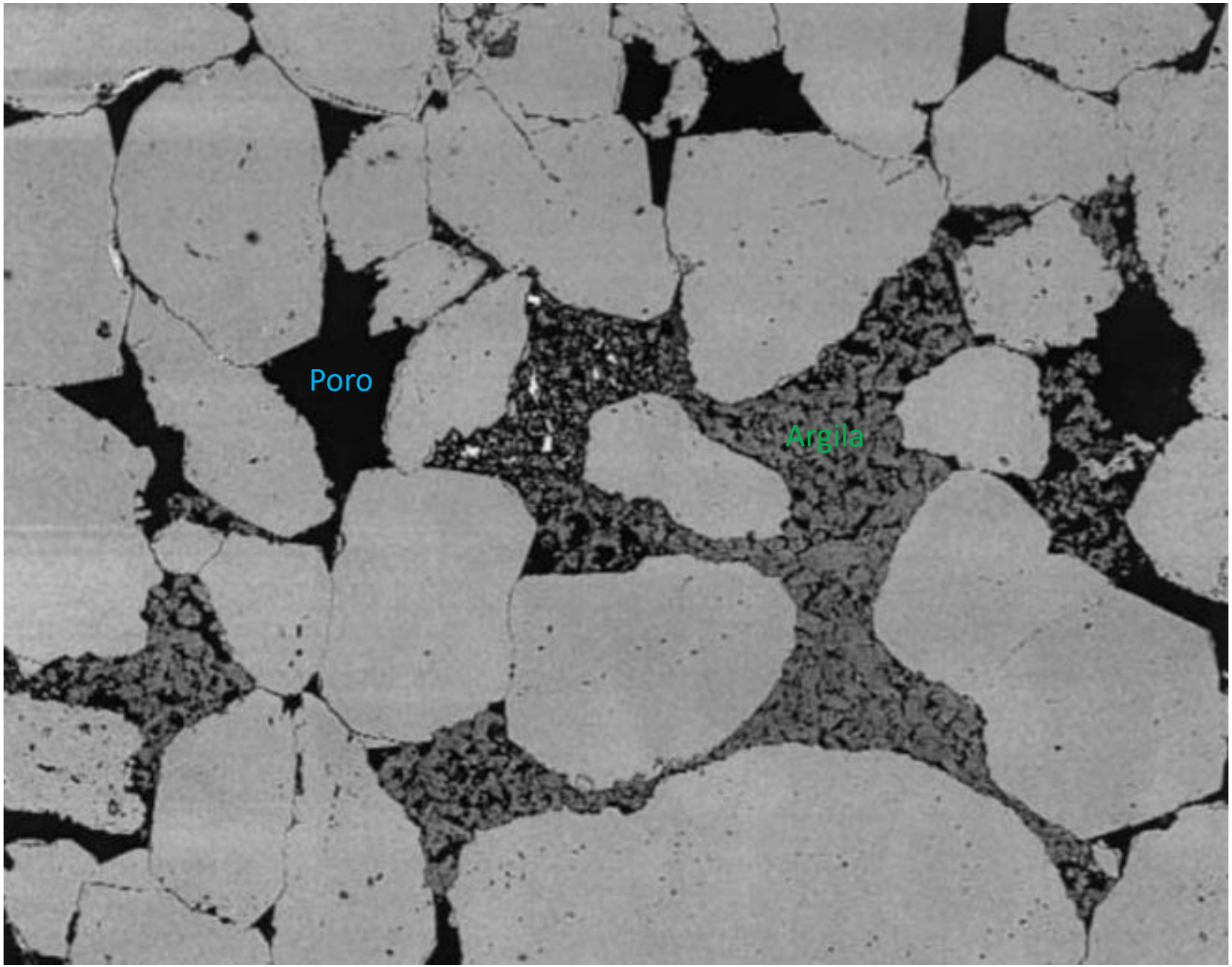
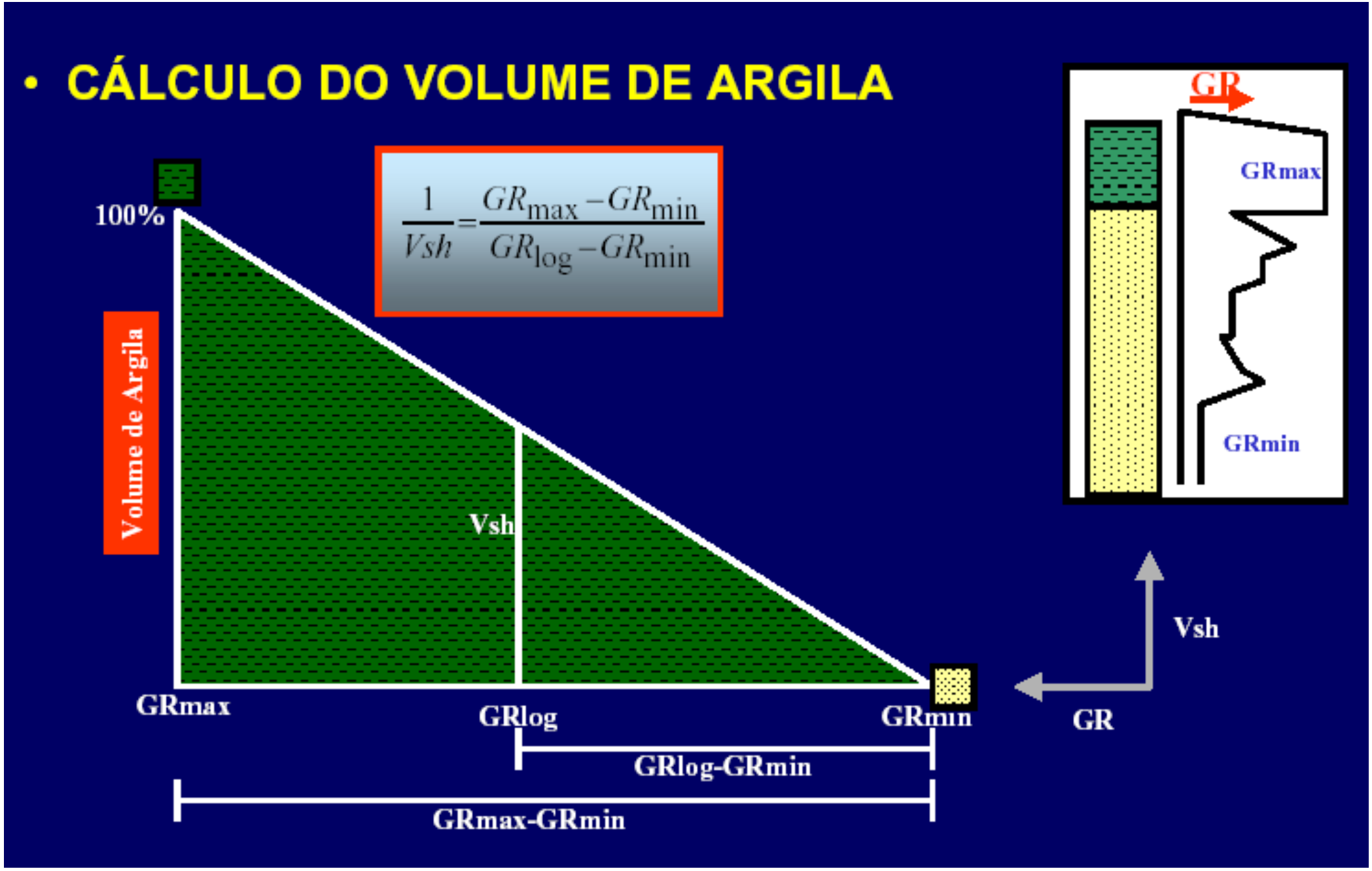


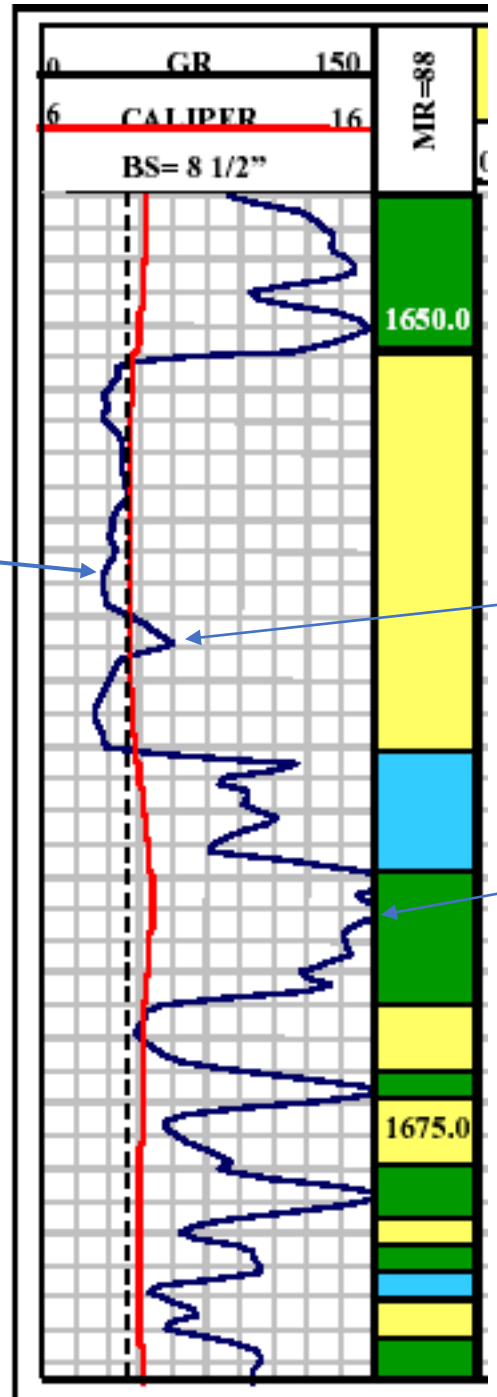
MEV (imagem de elétrons retroespalhados)

Estimativa do volume de argila pelo perfil de raios gama



Soeiro (2005)

$$V_{sh} = IG_R = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}}$$



Arenito “limpo”
(GR = 30 API)

Arenito com argila
(GR = 60 API; V_{sh}?)

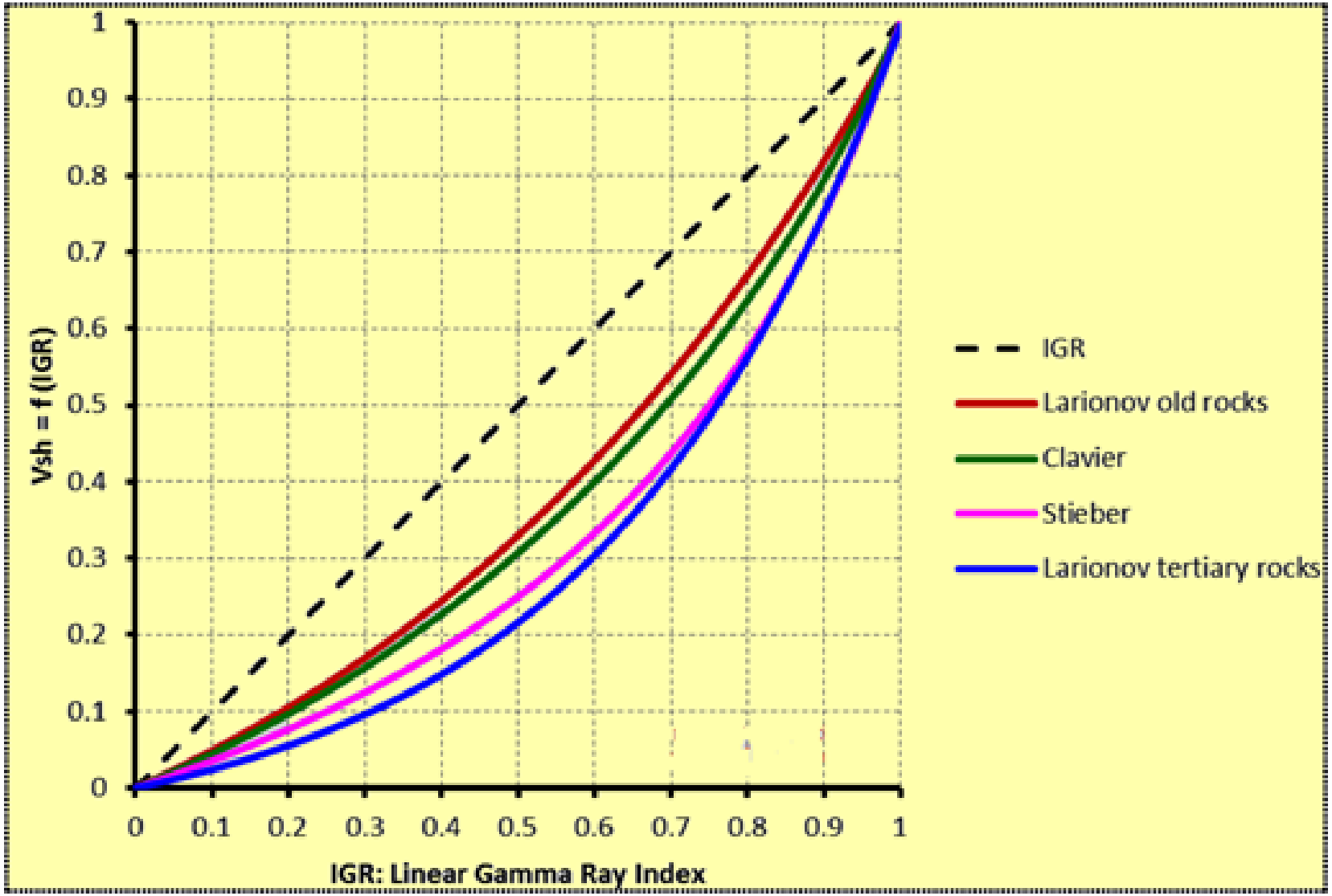
Folhelho (“argila”)
(GR = 150 API)

Soeiro (2005)

$$V_{sh} = IG_R = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}}$$

$$V_{sh} = IG_R = \frac{60 - 30}{150 - 30} = 0.25 = 25\%$$

$I_{GR} = V_{sh}$ superestima V_{sh}



Larionov[1] (1969) for Tertiary rocks:

$$V_{sh\ LarinovTertiaryRocks} = 0.083\left(2^{3.7I_{GR}} - 1\right)$$

Steiber[1] (1970):

$$V_{sh\ Steiber} = \left(\frac{I_{GR}}{3-2I_{GR}}\right)$$

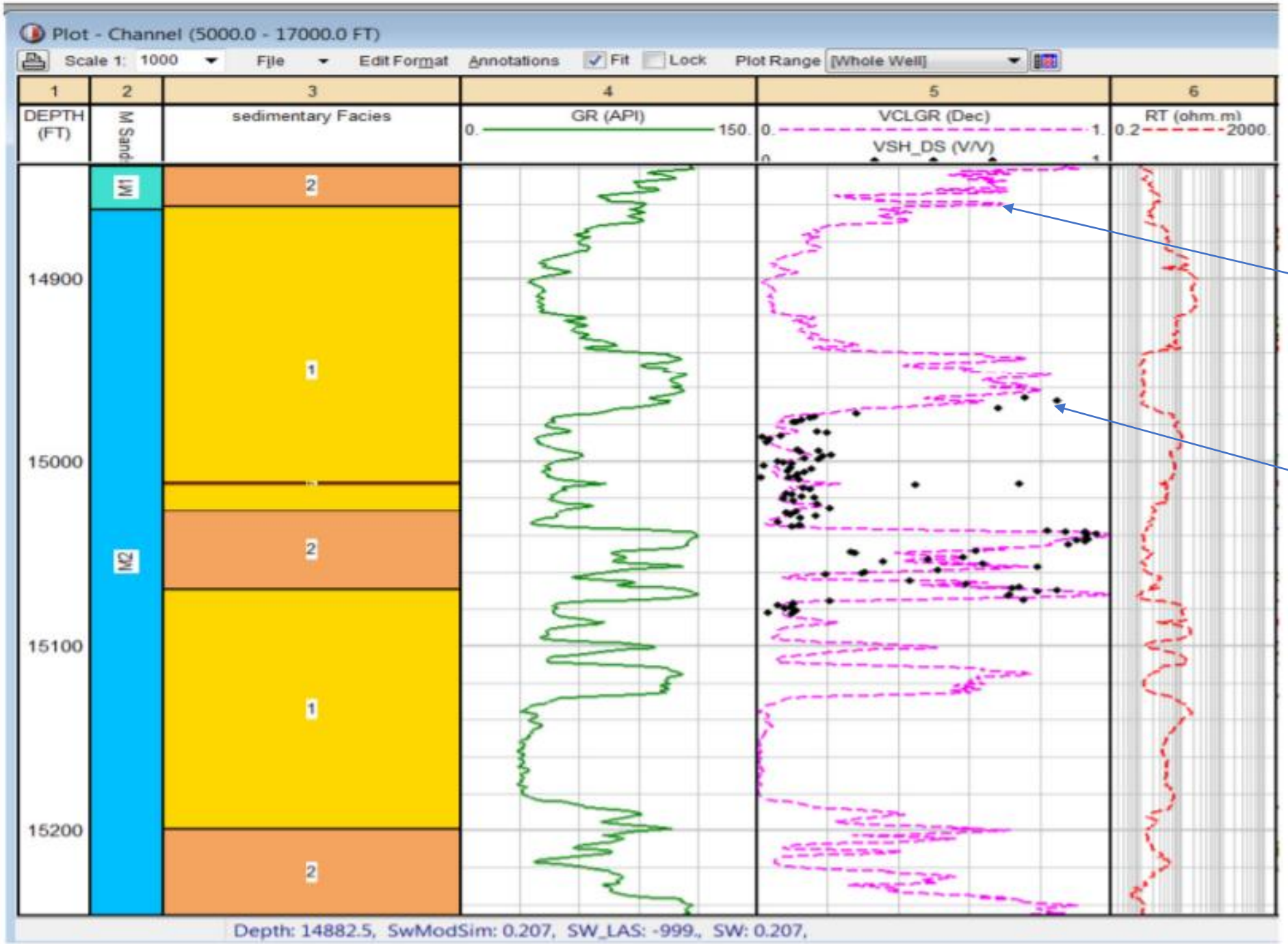
Clavier[1] (1971):

$$V_{sh\ Clavier} = 1.7\left[\left(3.38 - (I_{GR} = 0.7)^2\right)\right]^{1/2}$$

Larionov[1] (1969) for old rocks:

$$V_{sh\ Larinov\ Old\ Rocks} = 0.33\left(2^{2I_{GR}} - 1\right)$$

Soto et al. (2015)



Estimativa por GR

Medidas em amostra de testemunho

Soto et al. (2015)

Society of Petroleum Engineers

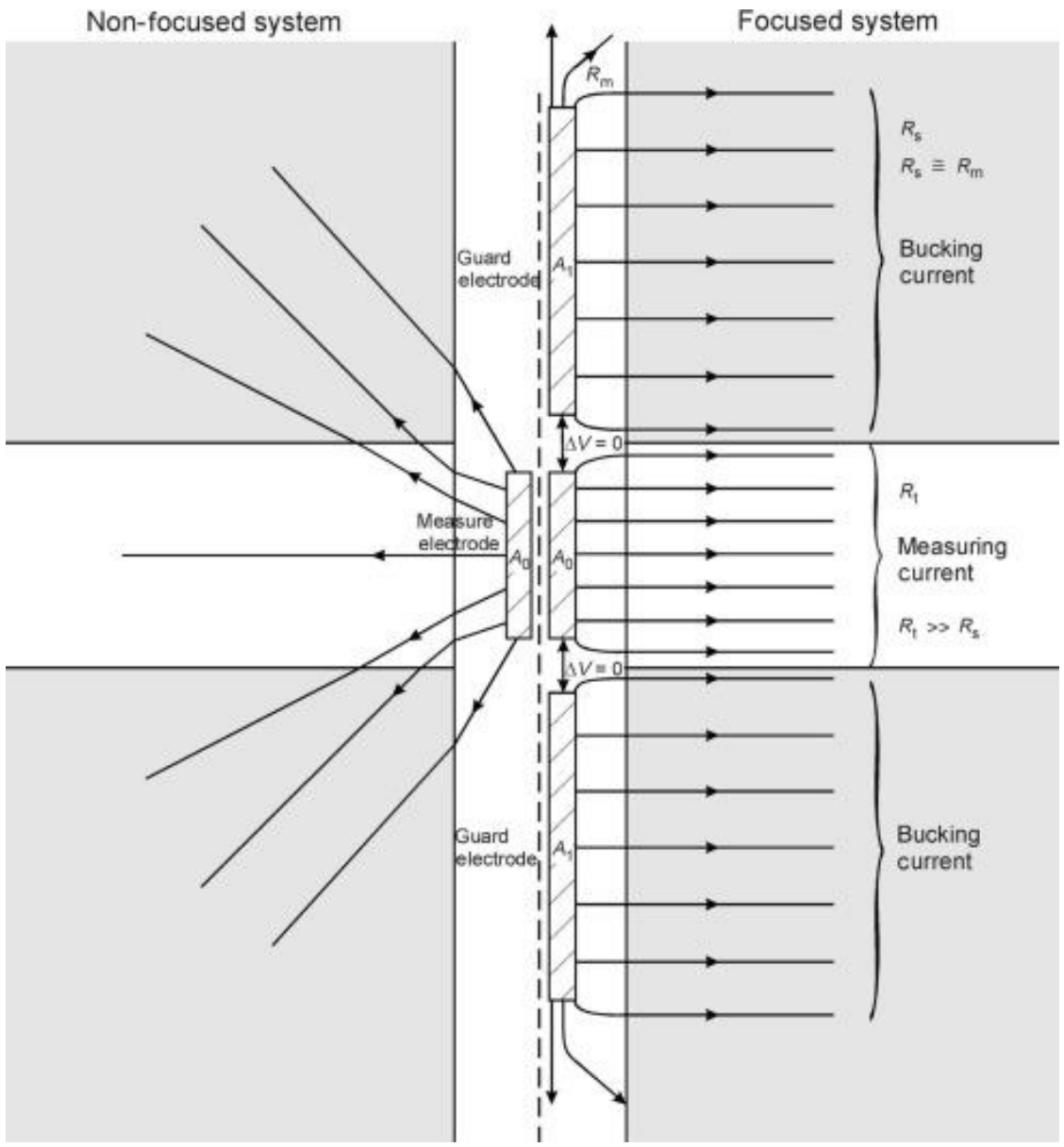
SPE-177224-MS

A Universal Equation to Calculate Shale Volume for Shaly-Sands and Carbonate Reservoirs

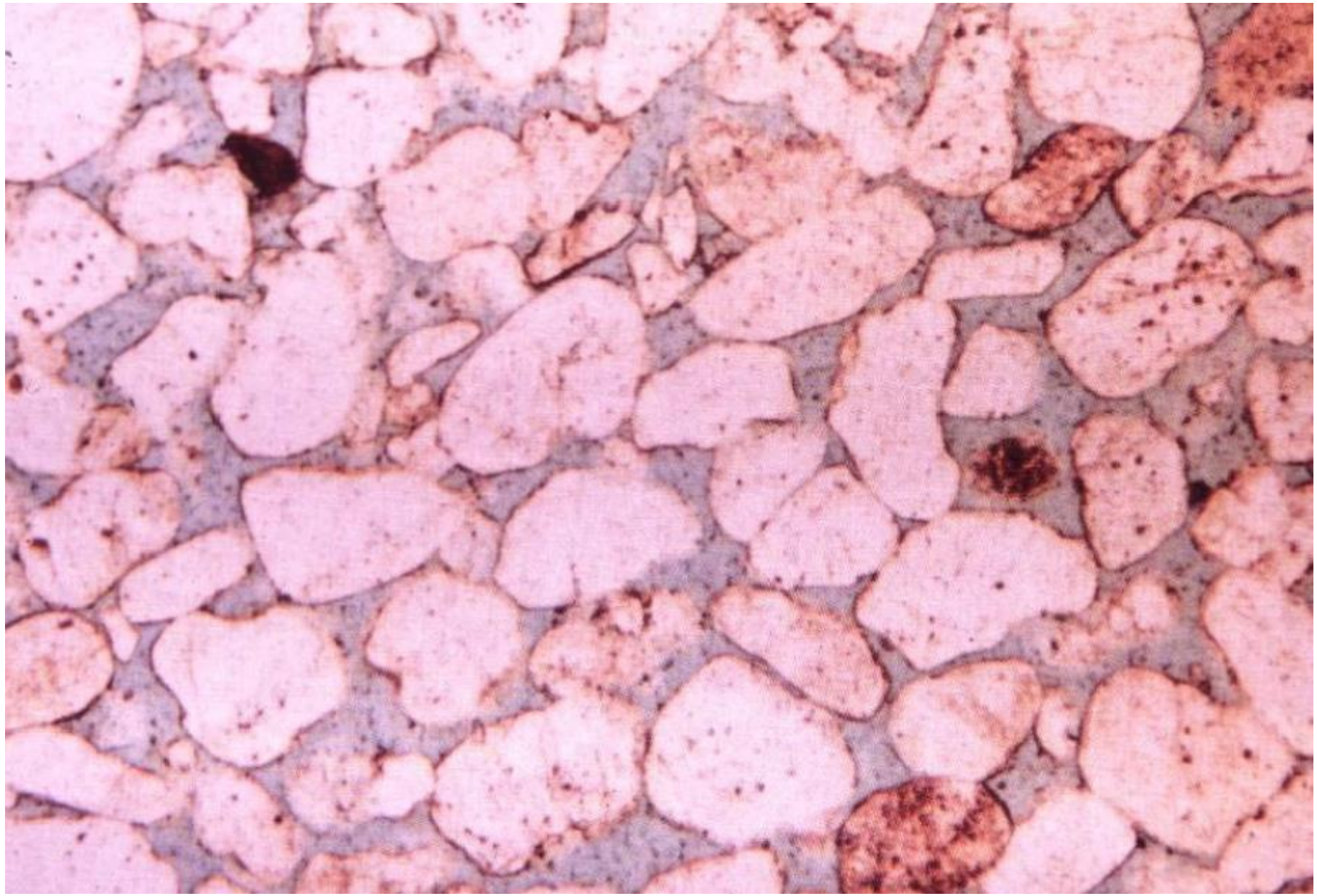
Soto O. David, and Soto B. Rodolfo, Digitoil; Soto O. Jonathan, Oliver Pasquel, and Duarry Arteaga, SGF GLOBAL

This paper was prepared for presentation at the SPE Latin American and Caribbean Petroleum Engineering Conference held in Quito, Ecuador, 18–20 November 2015.

Perfis de resistividade

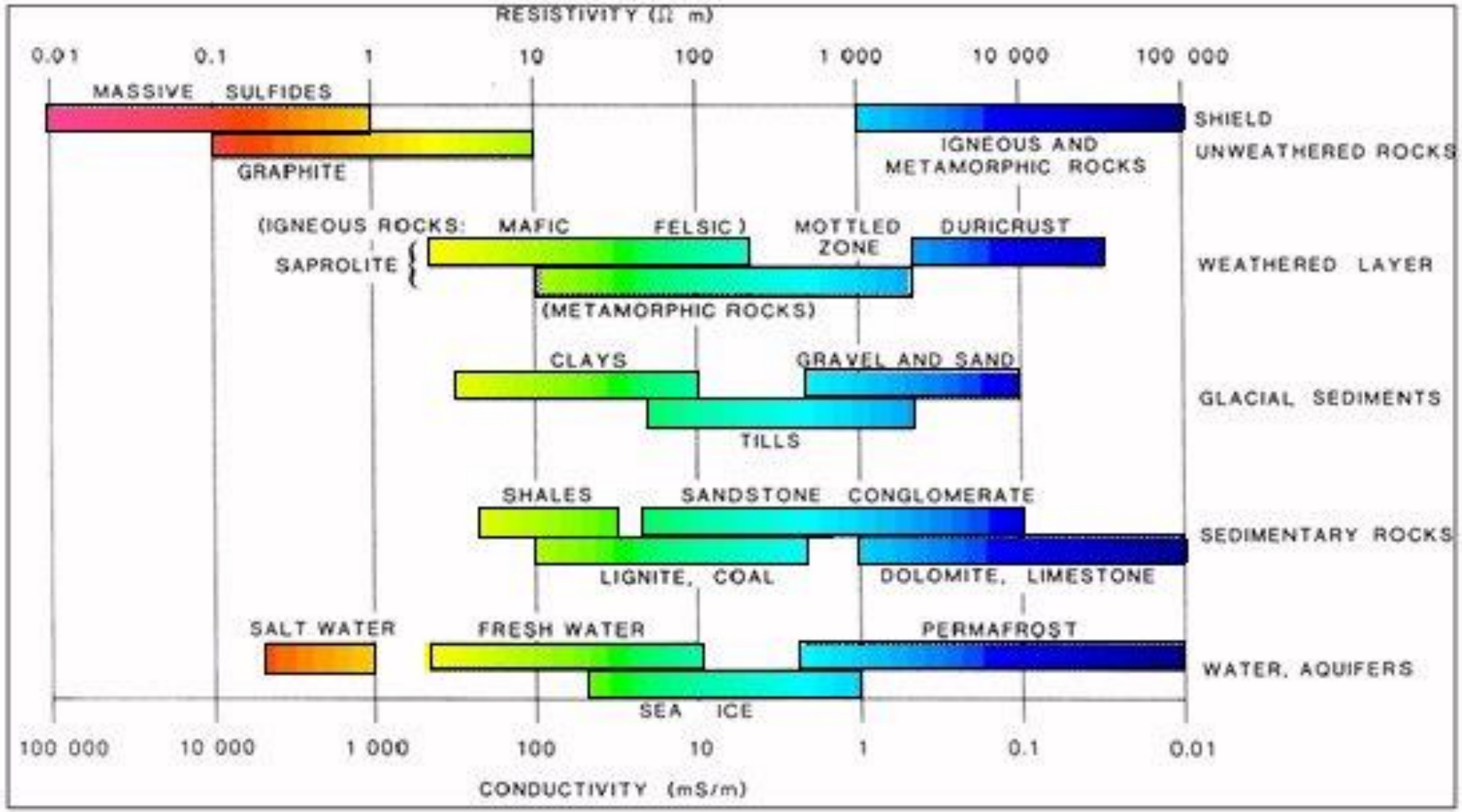


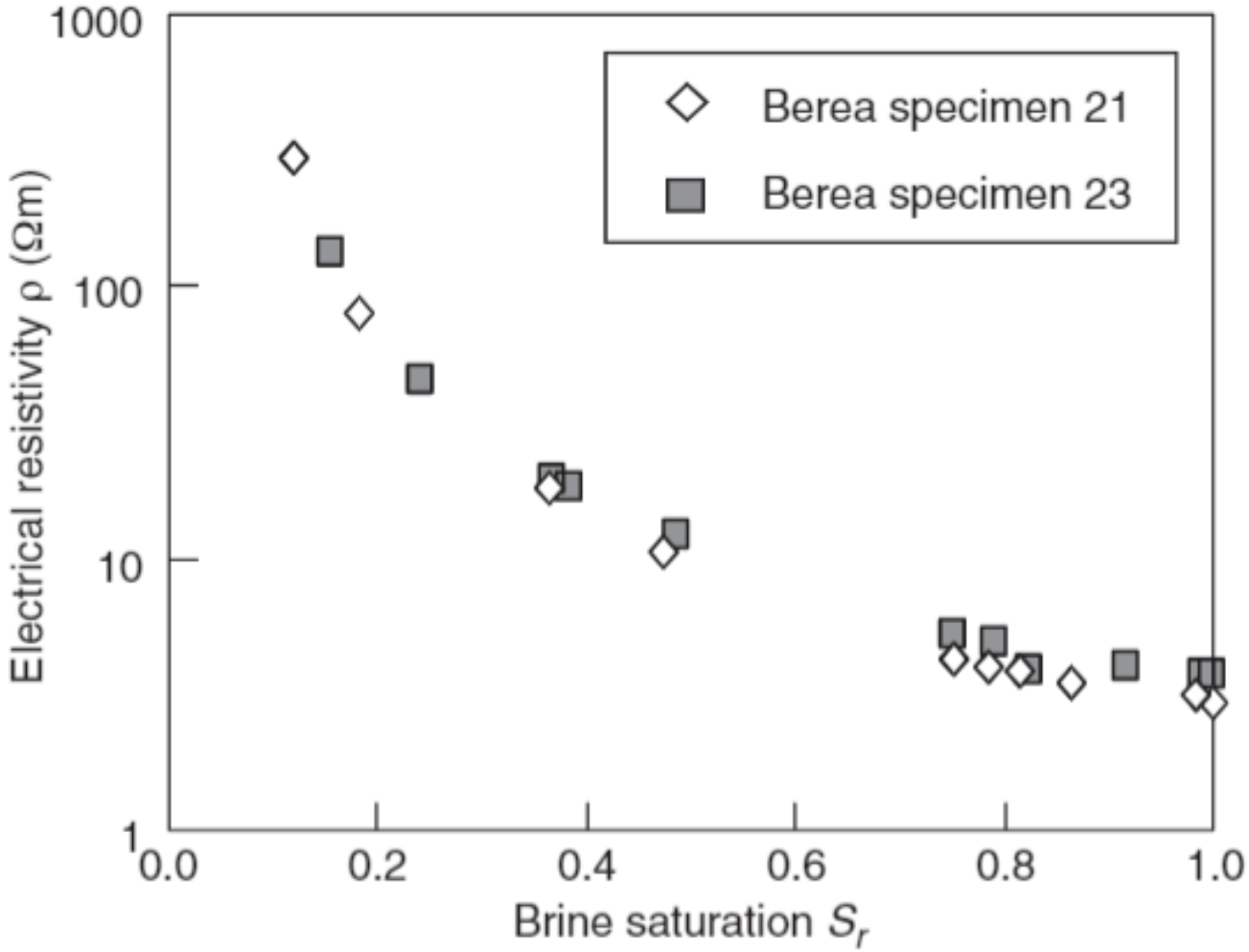
Tiab & Donaldson (2016)

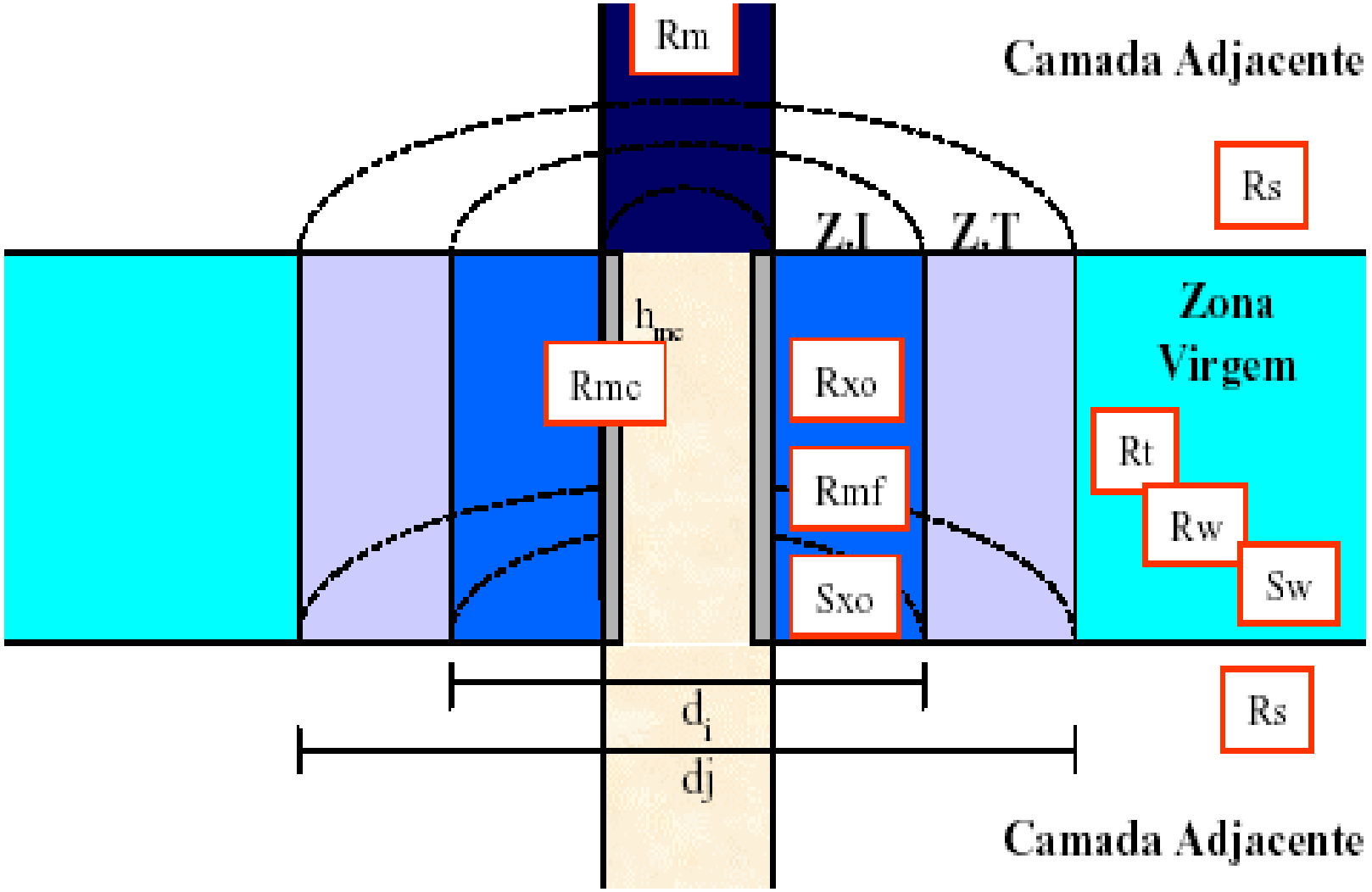


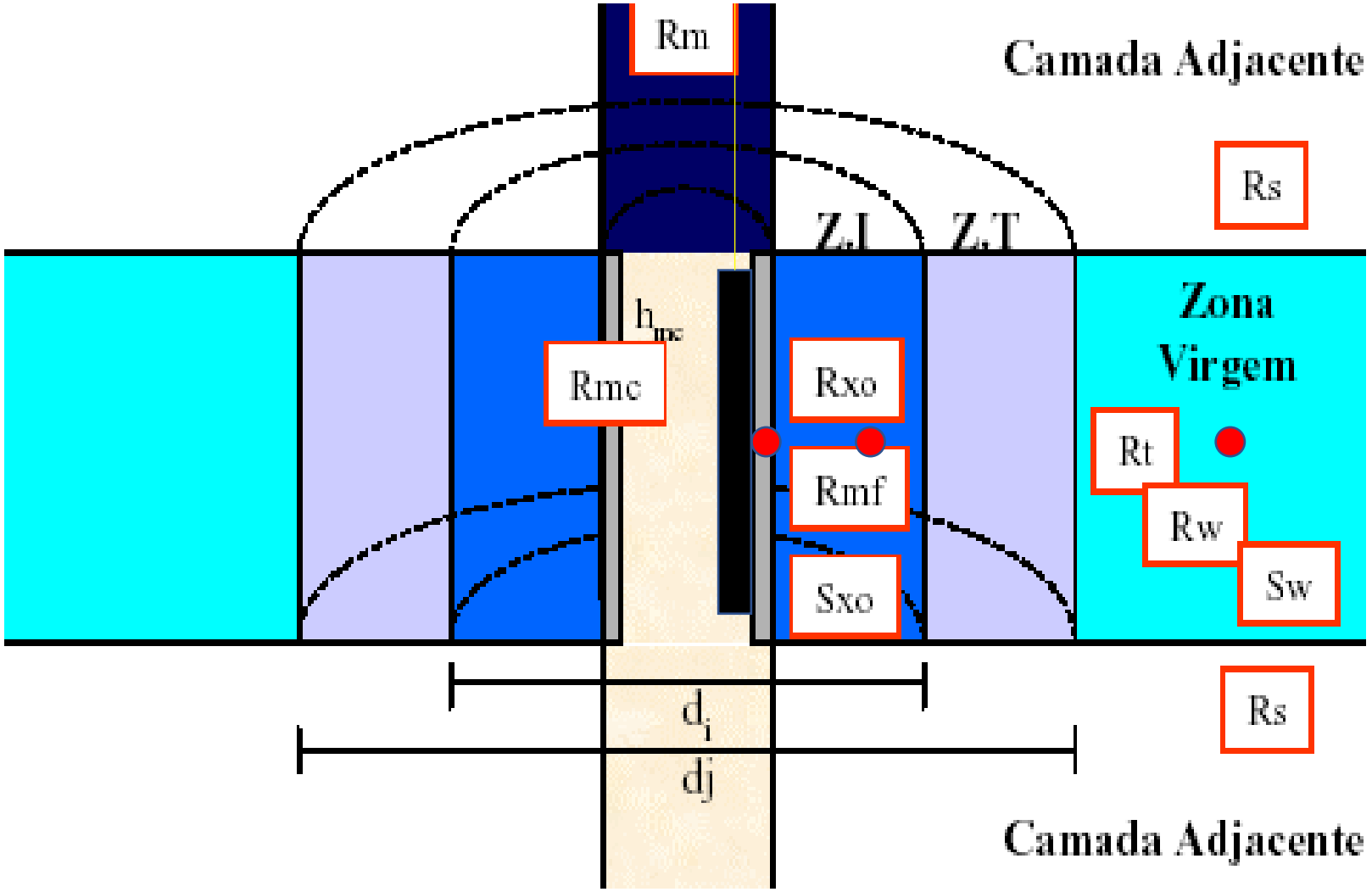
Material	Seismic (m/s)	Resistivity (ohm-m)
Igneous / Metamorphic		
Granite	4580 - 5800	$5 \times 10^3 - 10^8$
Weathered granite	305 - 610	$1 - 10^2$
Basalt	5400 - 6400	$10^3 - 10^6$
Quartz		$10^3 - 2 \times 10^6$
Marble		$10^2 - 2.5 \times 10^8$
Schist		$20 - 10^4$
Sediments		
Sandstone	1830 - 3970	$8 - 4 \times 10^3$
Conglomerate		$2 \times 10^3 - 10^4$
Shale	2750 - 4270	$20 - 2 \times 10^3$
Limestone	2140 - 6100	$50 - 4 \times 10^2$
Unconsolidated sediment		
Clay	915 - 2750	1 – 100
Alluvium	500 - 2000	10 – 800
Marl		1 – 70
Clay (wet)		20
Groundwater		
Fresh water	1430 - 1680	10 – 100
Salt water	1460 - 1530	0.2

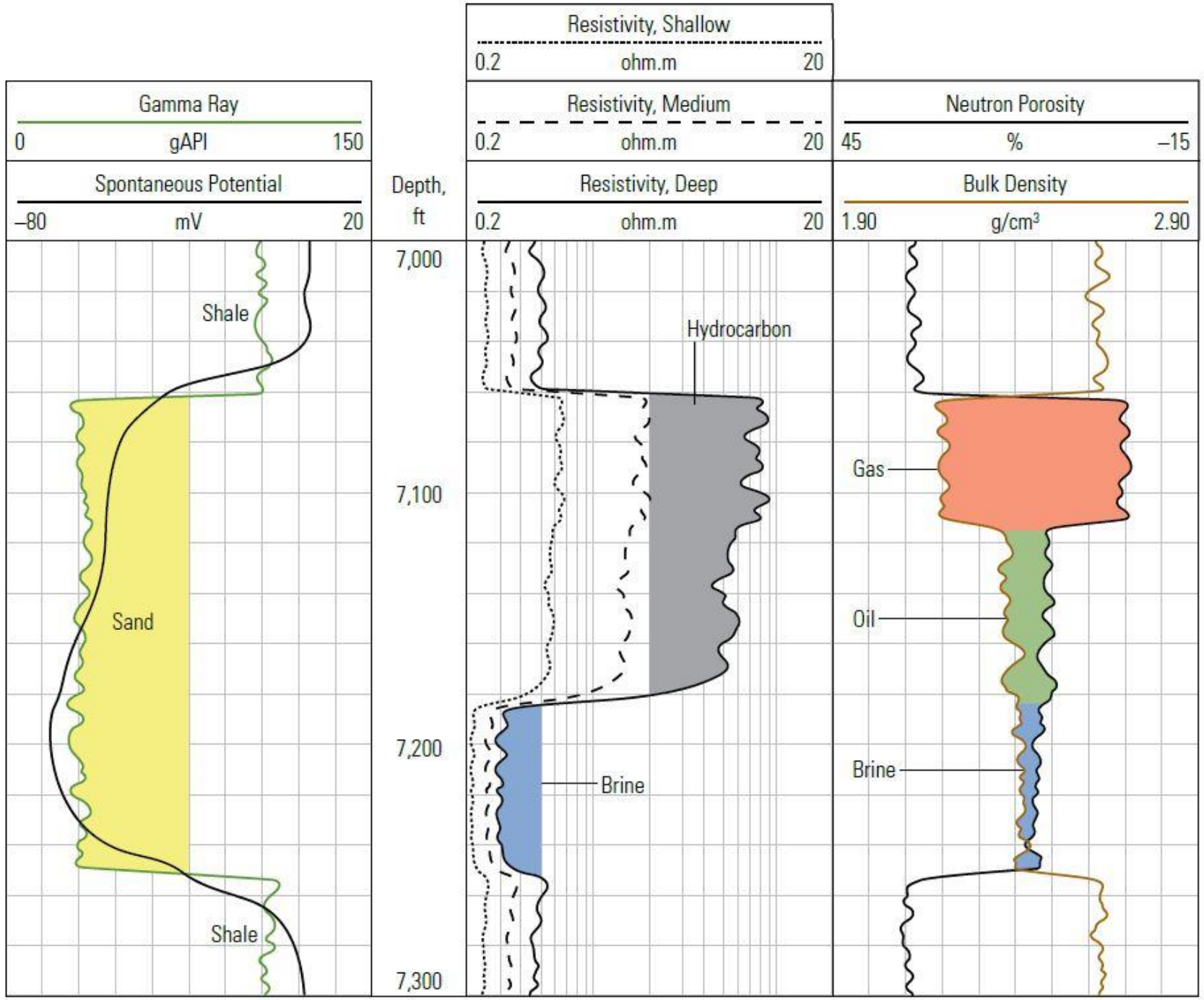
Abidin (2010)

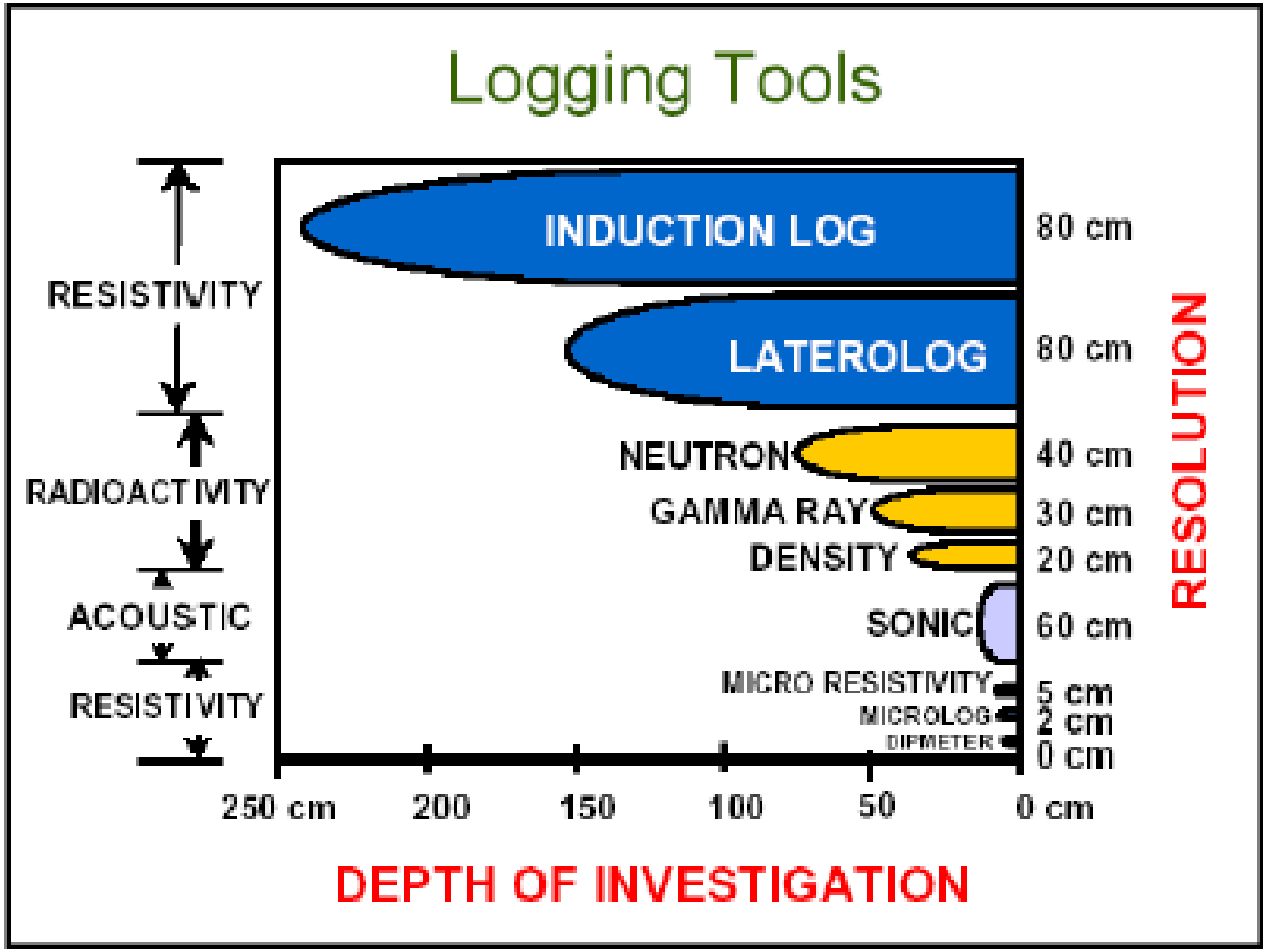

RESISTIVITY (Ω m)
0.01
0.1
1
10
100
1 000
10 000
100 000
MASSIVE SULFIDES
GRAPHITE
SHIELD
IGNEOUS AND METAMORPHIC ROCKS
UNWEATHERED ROCKS
(IGNEOUS ROCKS: MAFIC FELSIC)
SAPROLITE
MOTTLED ZONE
DURICRUST
WEATHERED LAYER
(METAMORPHIC ROCKS)
CLAYS
GRAVEL AND SAND
GLACIAL SEDIMENTS
TILLS
SHALES
SANDSTONE
CONGLOMERATE
SEDIMENTARY ROCKS
LIGNITE, COAL
DOLOMITE, LIMESTONE
SALT WATER
FRESH WATER
PERMAFROST
WATER, AQUIFERS
SEA ICE
100 000
10 000
1 000
100
10
1
0.1
0.01
CONDUCTIVITY (mS/m)

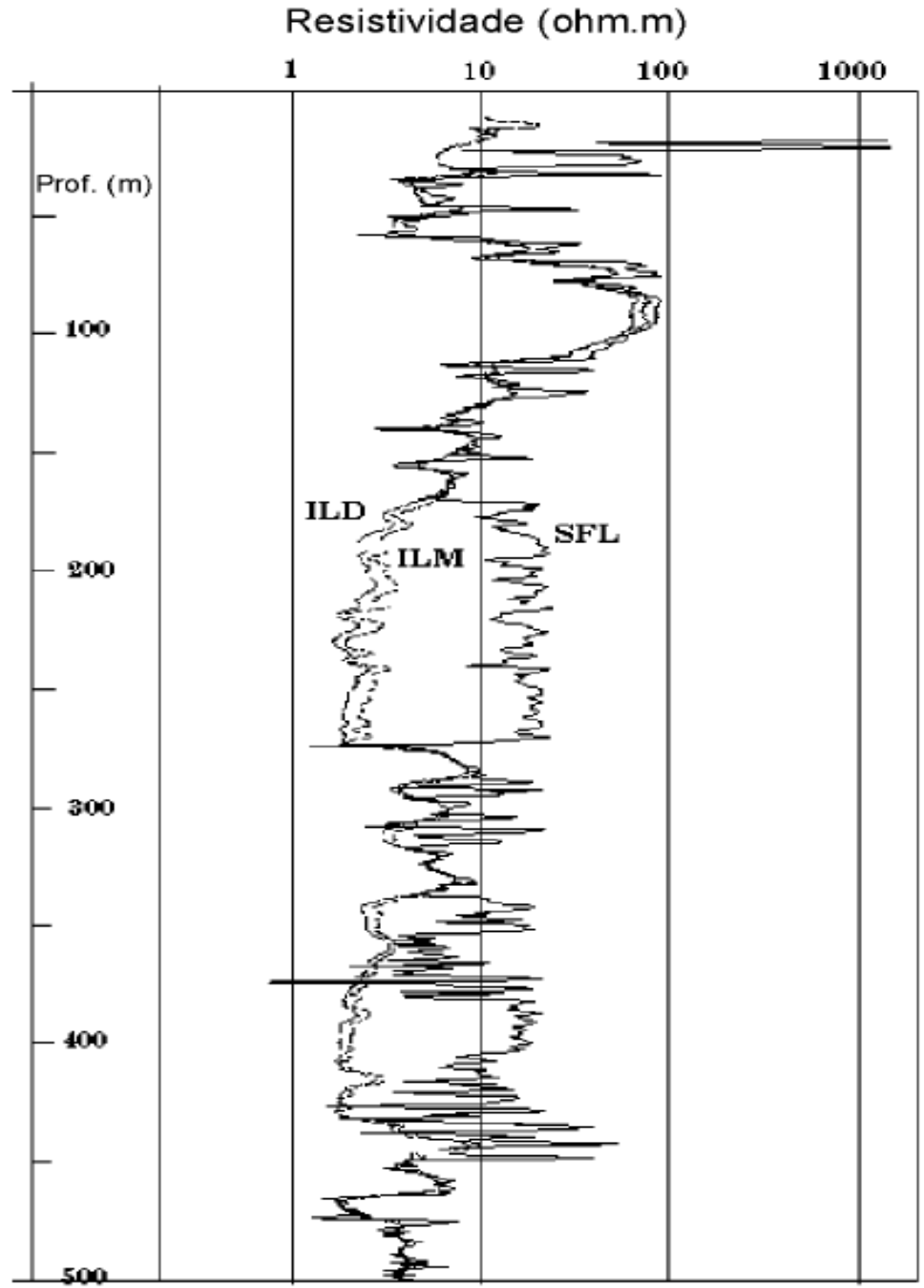

1000
100
10
1
Electrical resistivity ρ (Ωm)
Berea specimen 21
Berea specimen 23
0.0
0.2
0.4
0.6
0.8
1.0
Brine saturation S_r


Rm
Camada Adjacente
Rs
ZJ
ZT
Zona
Virgem
h_{mc}
Rmc
Rxo
Rmf
Sxo
Rt
Rw
Sw
Rs
d_i
dj
Camada Adjacente


Rm
Camada Adjacente
Rs
ZJ
ZT
Zona
Virgem
h_{mc}
Rmc
Rxo
Rmf
Sxo
Rt
Rw
Sw
Rs
d_i
dj
Camada Adjacente


Gamma Ray
0
gAPI
150
Spontaneous Potential
–80
mV
20
Resistivity, Shallow
0.2
ohm.m
20
Resistivity, Medium
0.2
ohm.m
20
Resistivity, Deep
0.2
ohm.m
20
Neutron Porosity
45
%
–15
Bulk Density
1.90
g/cm³
2.90
Depth, ft
7,000
7,100
7,200
7,300
Shale
Sand
Shale
Hydrocarbon
Brine
Gas
Oil
Brine


Logging Tools
RESISTIVITY
RADIOACTIVITY
ACOUSTIC
RESISTIVITY
INDUCTION LOG
LATEROLOG
NEUTRON
GAMMA RAY
DENSITY
SONIC
MICRO RESISTIVITY
MICROLOG
DIPMETER
80 cm
80 cm
40 cm
30 cm
20 cm
60 cm
5 cm
2 cm
0 cm
RESOLUTION
250 cm
200
150
100
50
0 cm
DEPTH OF INVESTIGATION



a SLF =rasa; ILM = intermediária; ILD = profunda