PERMEABILITY CORRELATIONS FOR CARBONATE & OTHER ROCKS

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Presentation rev. 3

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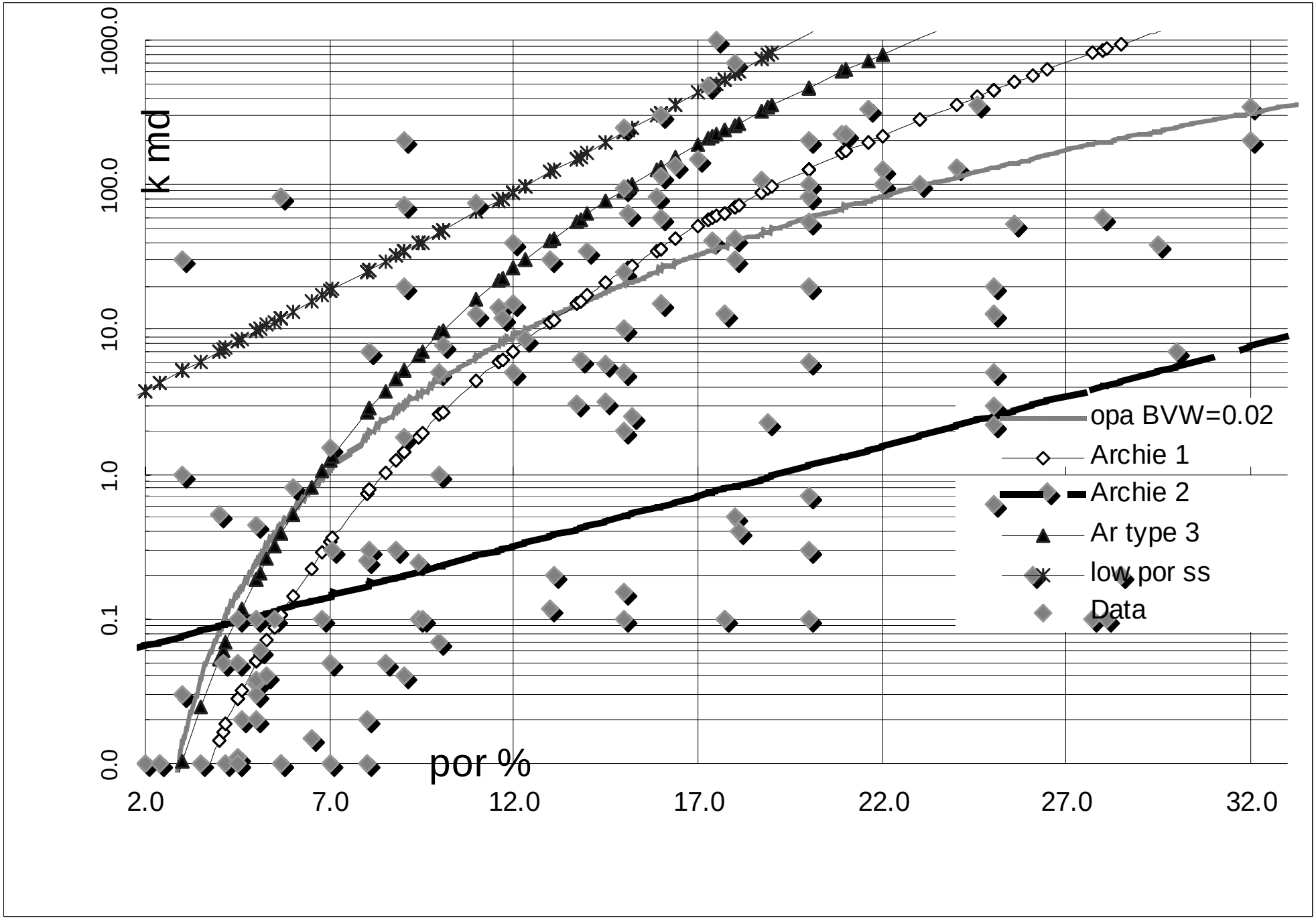
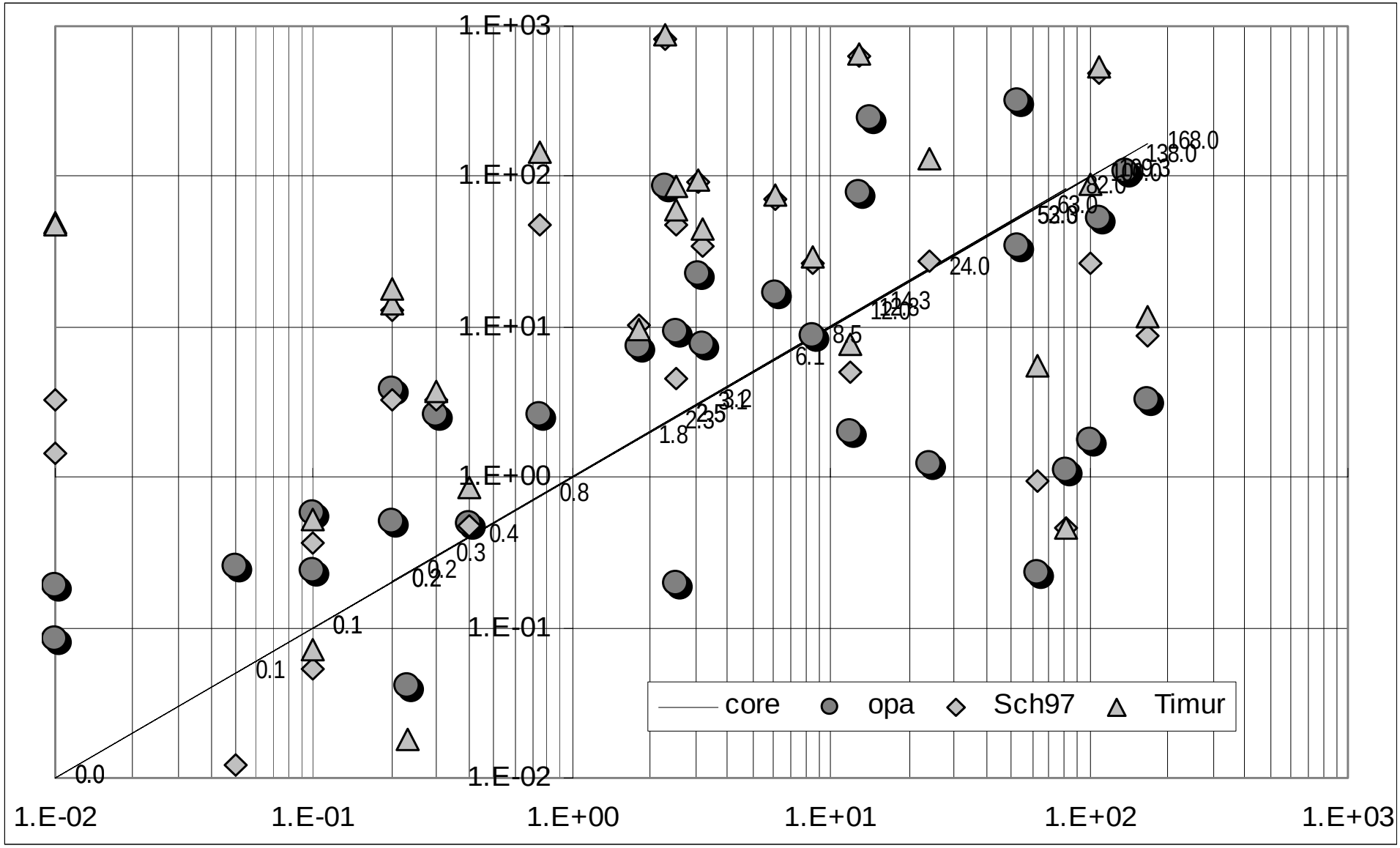
The form: $k\ (md) = 10\phi^{1.5}(1/Sw\text{-}c - 1)^{1.9}$
(if k calc > 200, use 1, not 10)

It is presented to improve description of potentially productive zones of carbonates.

Equations that do not use the form:
(1/Sw-c - 1) cannot accurately describe k at both low & high Swc, .i.e. at Swc=1, k must equal zero.

Following Graphs are comparisons:


k md
1000.0
100.0
10.0
1.0
0.1
0.0
por %
2.0
7.0
12.0
17.0
22.0
27.0
32.0
opa BVW=0.02
Archie 1
Archie 2
Ar type 3
low por ss
Data



Error w/ opa eqn is 10x's less than Sch97 and 20x's less Timur

Only 2 false negatives and 3 false positives at 1md cut point

MOBILE HC VALUE

Provided, a min k can be established, mobile HC factor is simply a mapping of the Bulk Volume Water Term, BVW. More correct K forms, with $(1/Swc - 1)^n$ are just more complex. Below is a simple derivation & recall (N^a)(N^-b)=N^(a-b) but ((N^a)^b)=N^(a*b):

Sw-c =BVW / ϕ in Timor's equation gives:

$K_{min} = \{92.6(\phi)^{2.2} / (Sw\text{-}c)\}^2 \Rightarrow \phi_{min} = \{\sqrt{K_{min}} * BVW/92.6\}^{0.313}$

and using these terms in the movable HC formula:

$\phi(S_{wc}^{0.2} - S_{wc})7760 = 7760\{\phi(\phi\, S_{wc}/\phi)^{0.2} - BVW\} =$

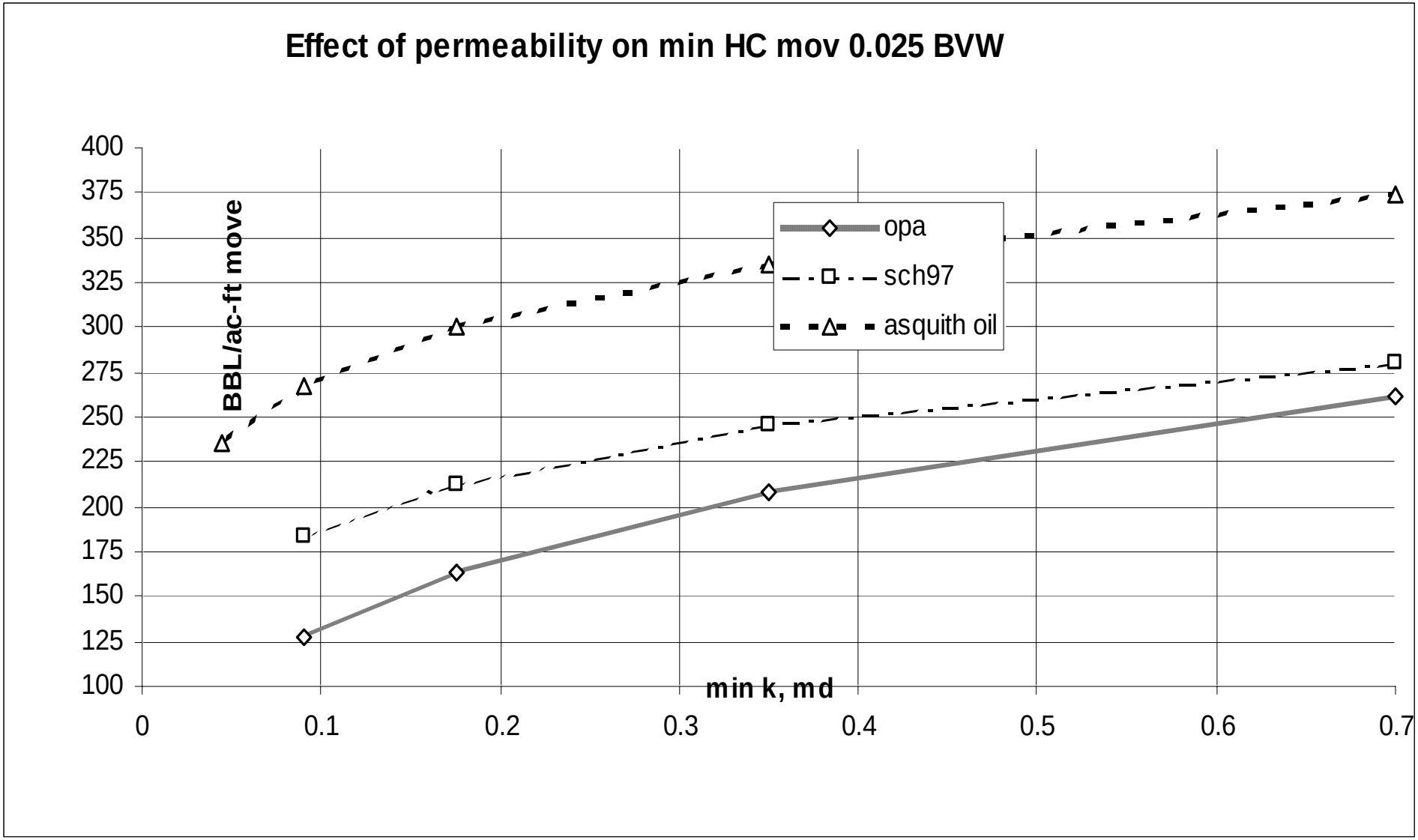
$BBL/AcFt = 7760\{\phi^{0.8}(BVW)^{0.2} - BVW\} \Rightarrow$

K_{min} RULE : $7760[\{\sqrt{K_{min}}/92.6\}^{0.25}(BVW)^{0.513} - BVW]$

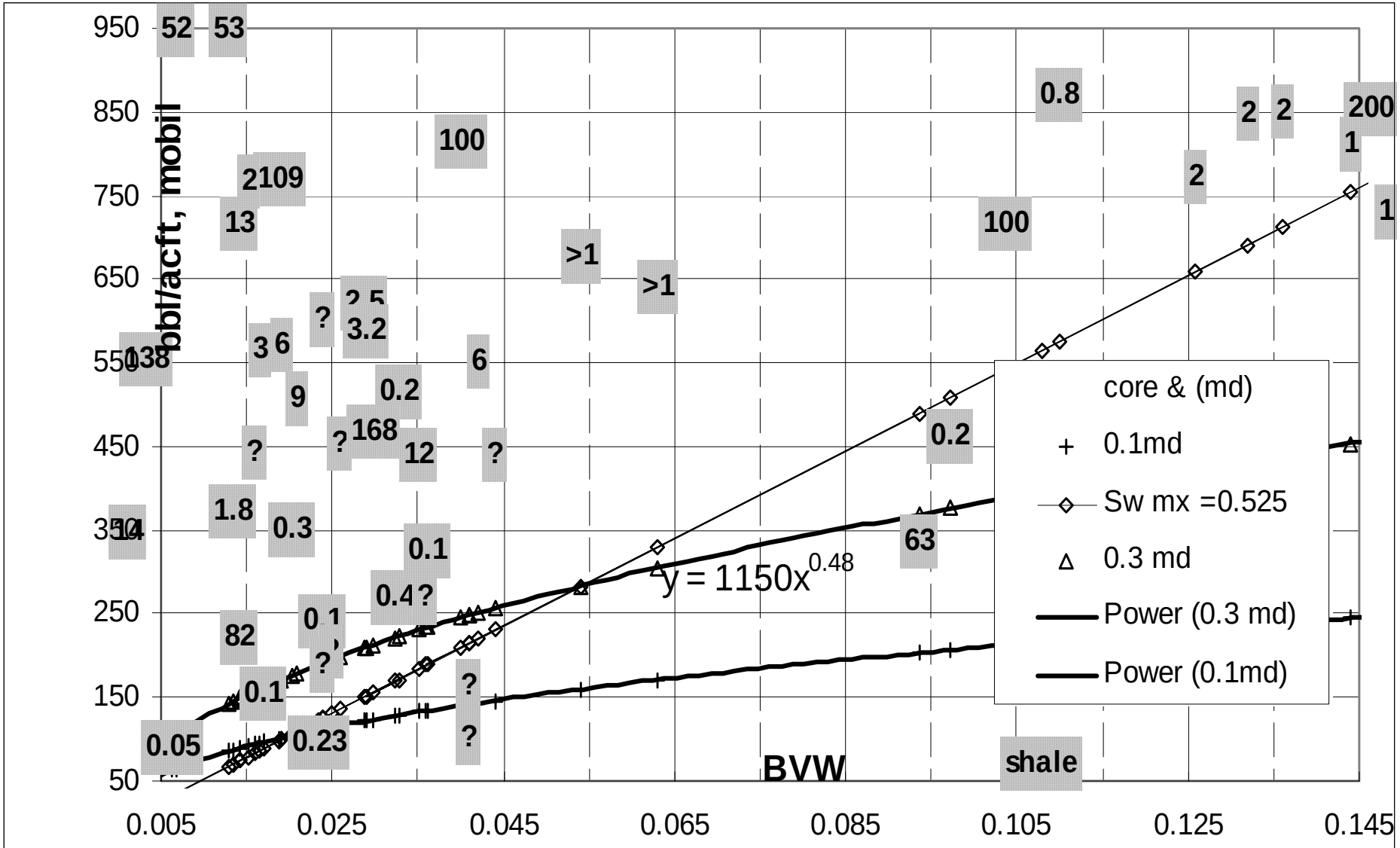
Other forms give similar results, but with limited range:

Max Swc RULE: $(BBL / AcFt)_{mo} = 7760(BVW)[(S_{wc})^{-0.8} - 1]$

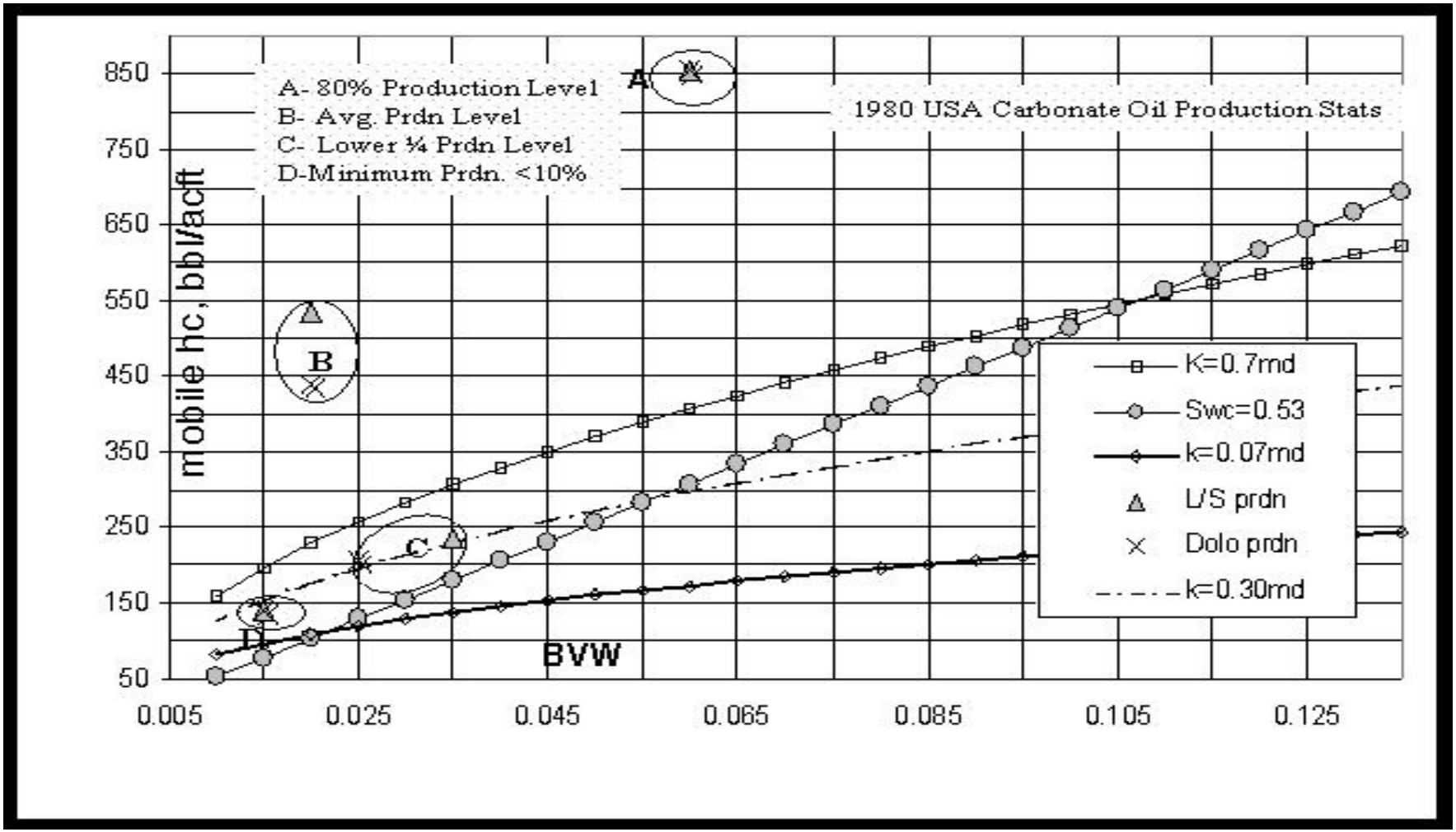
ϕ_{min} RULE : $(BBL / AcFt)_{mo} = 7760\{[\phi_{min}^{0.8}]BVW^{0.2} - BVW\}$



At each BVW, a MINIMUM mobility of BBL/AcFt is defined using a parametric of Porosity or Connate Water or k.



Plot of Core Data as BVW & Mobility Ratio: BBL/AcFt Minimum Proposed at 0.2md line or $780BVW^{0.44}$



Increased mobility ~ increased chance depo is economical 90% of all USA crb prdn from depo >130bbl / acft. US data shows: prospecting in low ϕ Siluran & older rocks; success rates 2-4x's higher if dolomites are tested compared to developing simular age & ϕ limestone rocks.

Lithology	Min bvw	max bvw	min bbl/AcFt	mx bbl/AcFt
vug carb	0.005	0.015	76	123
vug & IX carb	0.015	0.025	123	154
.Intr gran crb.	0.025	0.040	154	189
Chalk carb	0.050	0.100	189	283
$780BVW^{0.44}$	<=crb			

2^{nd} ϕ &Vug Carbs: =>bimodal pores

In logging terms: movable HC is:

$BBL/AcFt = 7760[\sqrt{a}]*[\sqrt{(Rmf/Rxo)} - \sqrt{(Rw/Rt)}]$

at irreducible H2O= $7760\{\sqrt{(Rw/aRt)}\}[S_{wc})^{-0.8} - 1]$

Where a is term to make $F = (a/\phi^2)$, typically a=1 in carb.

Summary

- Typical conditions, production < 900 & >130 bbl / ac-ft.
- Mobile HC expressed as BBL / Acft is a handy way to evaluate deposit, provided lithology is understood
- The closer values are to litho-minimums, the less the chances of economic HC extraction
- Low mobility values also indicate low permeability, w / o bimodal pores
- Higher values indicate higher effective porosity
- Watch for chalk & silt porosity types as they have higher min's
- Rocks with <140 bbl/AcFt = cap rocks unless Vug or coarse ss porosity types
- USA prdn data show Vug type more often dolomite, more brittle & dolomites more often in Siluran & older formations.

Upper Ordovician Zone, Clean Carbonate, Western Latvia

movable	HC		
36 wells	W. Latvia		
bbl/acft	bbl/acft		
	200	235	max
	94	131	avg
	60	90	std
		36	n
IX LS	clean		

Indication in 36 wells: this zone is a Cap Rock, typically <140 & does not contribute to oil flow, remove this zone in Htests.

Well J-E6

Horner Analysis	Compare
Danish	*OPA* /core
t, m *10*	*0.62*
por % *11*	17.4
k, md *2.5*	40.5

Horner gives md-m
Geol. Factors = thickness
cores show ~1m sucrosic LS

Indications are: oil flow is from thin lower sucrosic LS/Dolo

Thanks for hearing my considerations. A more detailed Discussion is available by email request.

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