$$q_{\bar{o}} = \frac{k \cdot h}{18.68 \cdot \left(ln\left(\frac{r_e}{r_w}\right) - 0.75 + s\right)} \int_{p_{wf}}^{p_R} \frac{k_{ro}}{\mu_o \cdot B_o} dp$$

$= \int_{p_{wf}}^{p_R} \frac{k_{ro}}{\mu_o B_o} dp = m(p_R) - m(p_{wf})$

$= \int_0^{p_{wf}} \frac{k_{ro}}{\mu_o B_o} dp = m(p_{wf})$

Not the same gas m function !!

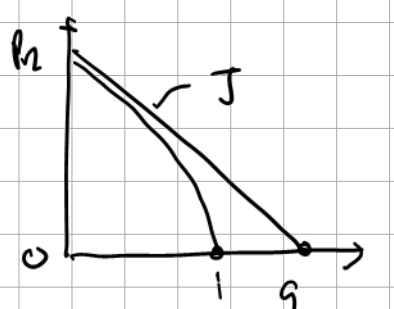
$\int \frac{p\, dp}{z \mu_g}$

Vogel (V = 0.2)

$$q_{\bar{o}} = q_{\bar{o},max} \left[1 - V \cdot \frac{p_{wf}}{p_R} - (1 - V) \cdot \left(\frac{p_{wf}}{p_R}\right)^2\right]$$

$$= \frac{k \cdot h \cdot \left[\left(\frac{k_{ro}}{\mu_o \cdot B_o}\right)_{@p_R}\right] \cdot (p_R - 0)}{18.68 \cdot \left(ln\left(\frac{r_e}{r}\right) - 0.75 + s\right) \cdot 1.8} = \frac{J}{1.8} \cdot pR$$

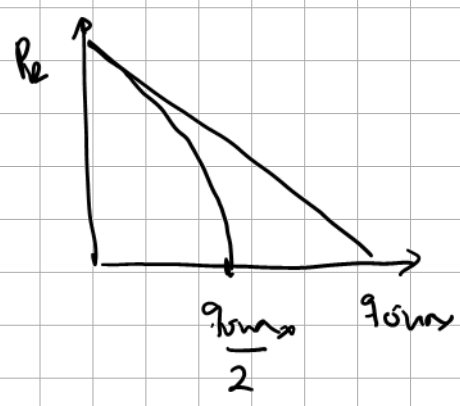
(J → $q_{\bar{o}max}$)



Fetkovich

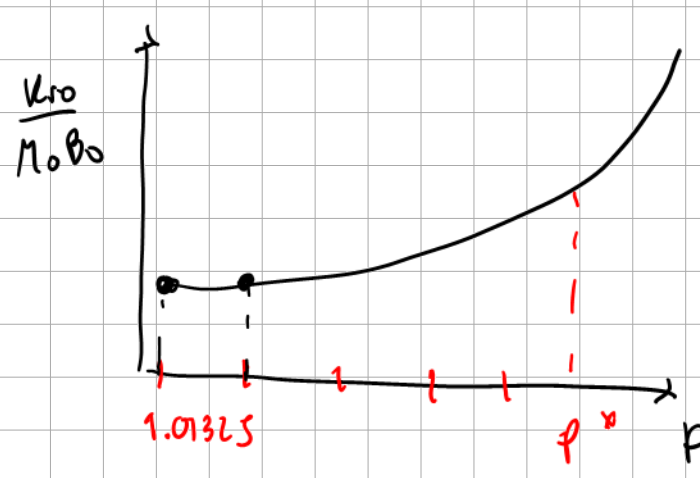
$$q_{\bar{o}} = q_{\bar{o},max} \left[1 - \left(\frac{p_{wf}}{p_R}\right)^2\right]$$

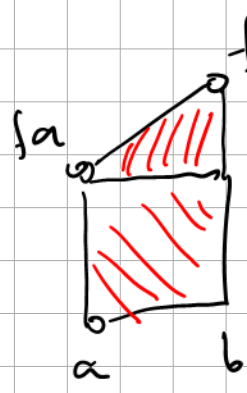
$$\frac{k \cdot h \cdot \left[\left(\frac{k_{ro}}{\mu_o \cdot B_o}\right)_{@p_R}\right] \cdot p_R}{18.68 \cdot \left(ln\left(\frac{r_e}{r_w}\right) - 0.75 + s\right) \cdot 2} = \frac{J}{2} \cdot pR$$



oil m function in VBA;

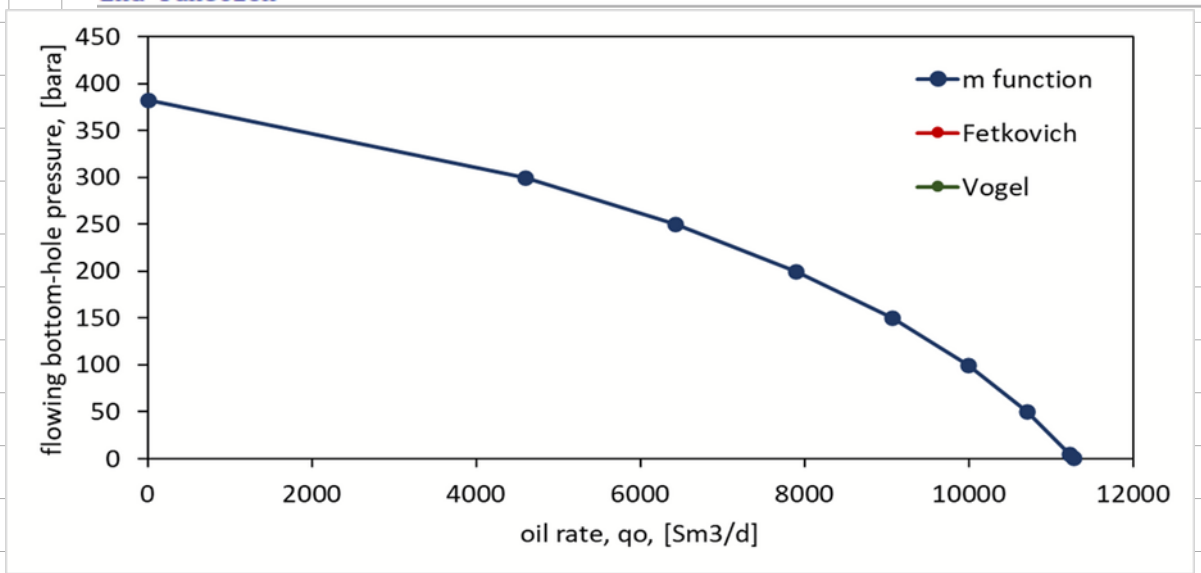
```
Function m_function_oil(p, col, Matrix As Range)
    'p in bara
    'n number of intervals to use in the integration
    p1 = 1.01325
    p2 = p
    If p2 - p1 > 40 Then
        n = Round((p2 - p1) / 10, 0)
    Else
        n = 10
    End If
    DP = (p2 - p1) / n
    pj = p1
    Sum = 0
    fa = tabinterpol(pj, col, Matrix)
    For J = 1 To n
        pj = pj + DP
        fb = tabinterpol(pj, col, Matrix)
        Sum = Sum + (DP * (fa + fb)) * 0.5
        fa = fb
    Next
    m_function_oil = Sum
End Function
```



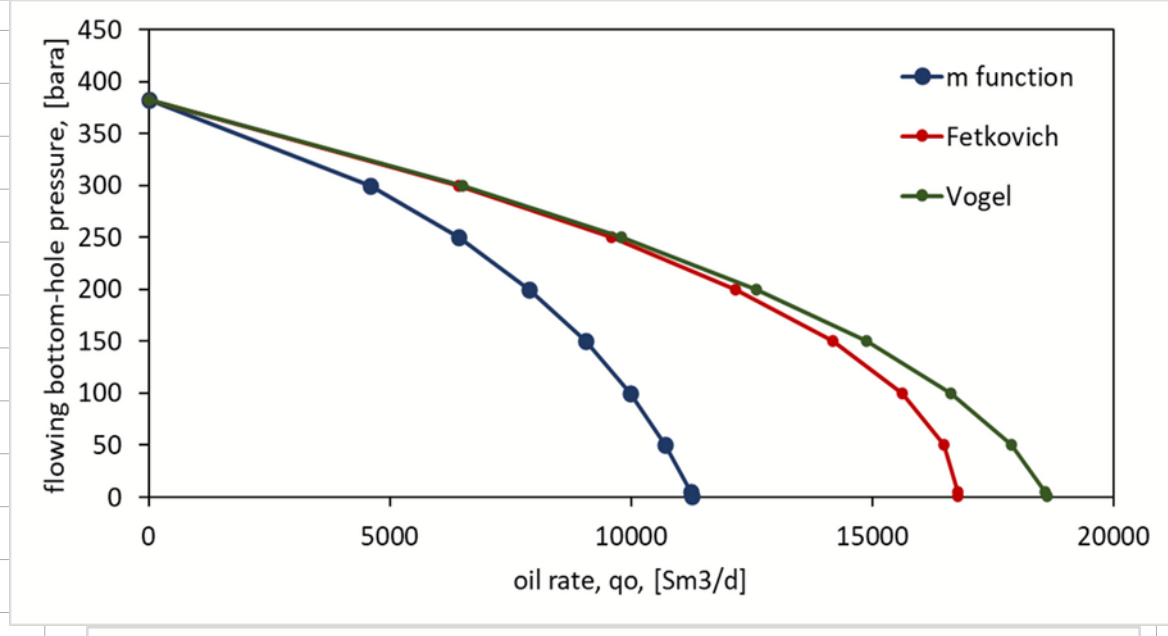


$Area = (fa + fb) \cdot \frac{(b-a)}{2}$

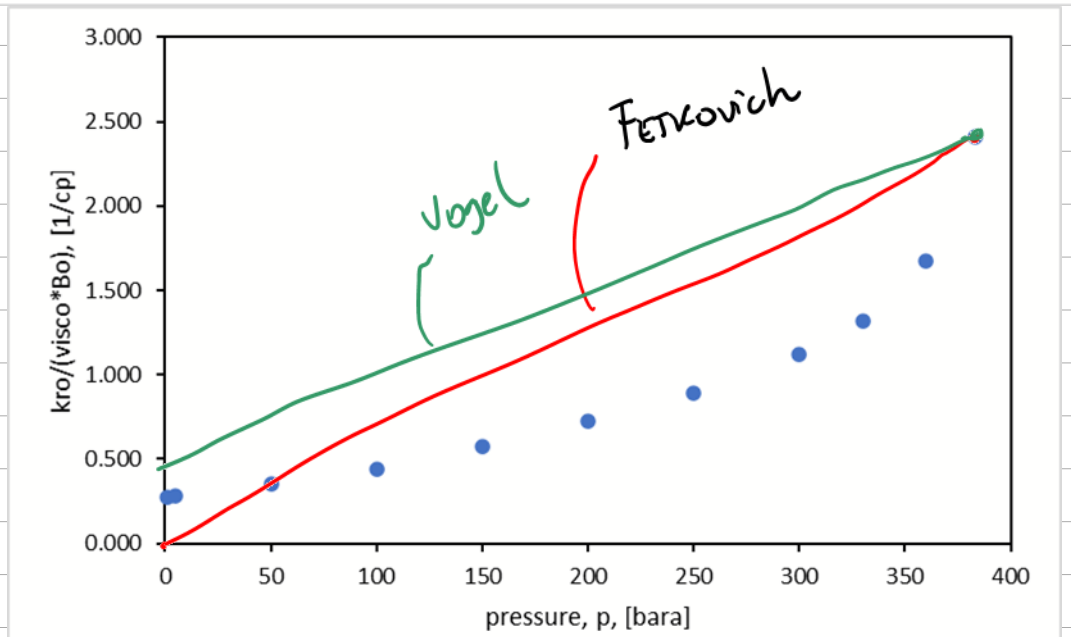
```
Function ipr_sat_oil_qo_m_function(k, h, re, rw, s, mpR, mPwf)
    'ipr_sat_oil, oil rate in Sm3/d, calculated with the m function
    'k, permeability, [md]
    'h, layer height, [m]
    're external radius of reservoir [m]
    'rw, wellbore radius [m]
    's, skin factor [-]
    'mpR, m function at reservoir pressure [bara/cp]
    'mpwf, m functino at flowing bottom-hole pressure [bara/cp]
    ipr_sat_oil_qo_m_function = k * h * (mpR - mPwf) / ((Log(re / rw) - 0.75 + s) * 18.68)
End Function
```



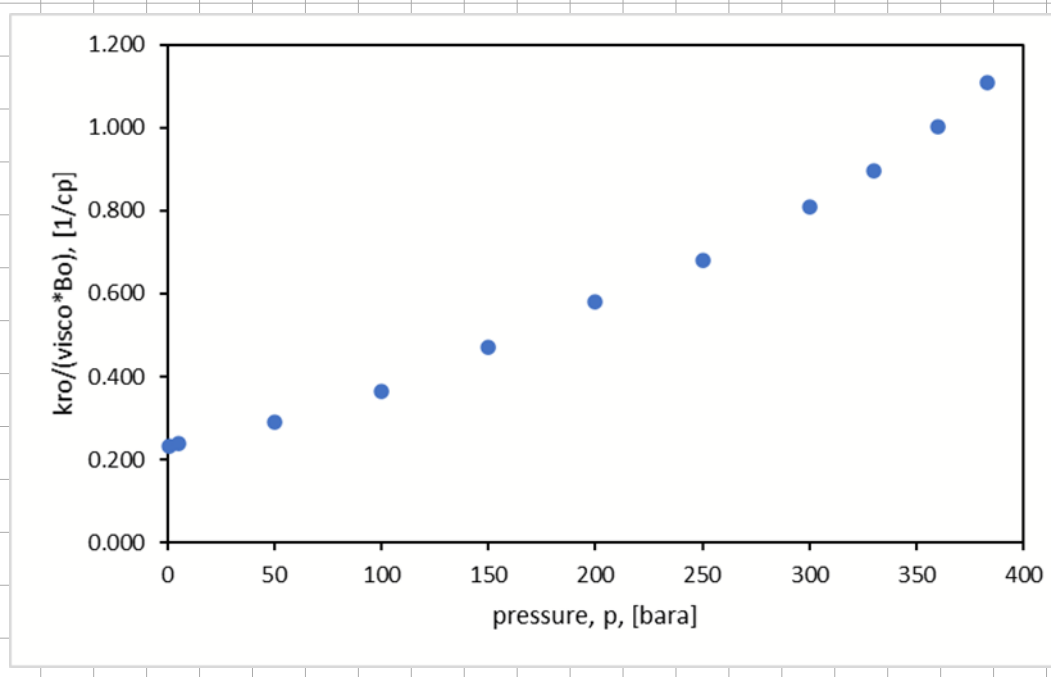

```
Function ipr_sat_oil_qo_Fetkovich(k, h, re, rw, s, pR, Pwf, Bo_pR, visco_pR, kro_pR)
    'ipr_sat_oil, oil rate in Sm3/d, calculated with the m function
    'k, permeability, [md]
    'h, layer height, [m]
    're external radius of reservoir [m]
    'rw, wellbore radius [m]
    's, skin factor [-]
    'pR, reservoir pressure [bara]
    'pwf, flowing bottom-hole pressure [bara]
    'kro_pR oil relative permeability at reservoir pressure, [-]
    'visco_pR oil viscosity at reservoir pressure [cp]
    'Bo_pR oil formation volume factor at reservoir pressure, [m3/Sm3]
    J = k * h * (kro_pR / (visco_pR * Bo_pR)) / ((Log(re / rw) - 0.75 + s) * 18.68)
    qomax = J * (pR - 0) / 2
    ipr_sat_oil_qo_Fetkovich = qomax * (1 - (Pwf / pR) ^ 2)
End Function
```




```
Function ipr_sat_oil_qo_Vogel(k, h, re, rw, s, pR, Pwf, Bo_pR, visco_pR, kro_pR)
    'ipr_sat_oil, oil rate in Sm3/d, calculated with the m function
    'k, permeability, [md]
    'h, layer height, [m]
    're external radius of reservoir [m]
    'rw, wellbore radius [m]
    's, skin factor [-]
    'pR, reservoir pressure [bara]
    'pwf, flowing bottom-hole pressure [bara]
    'kro_pR oil relative permeability at reservoir pressure, [-]
    'visco_pR oil viscosity at reservoir pressure [cp]
    'Bo_pR oil formation volume factor at reservoir pressure, [m3/Sm3]
    J = k * h * (kro_pR / (visco_pR * Bo_pR)) / ((Log(re / rw) - 0.75 + s) * 18.68)
    qomax = J * (pR - 0) / 1.8
    ipr_sat_oil_qo_Vogel = qomax * (1 - 0.2 * (Pwf / pR) - 0.8 * (Pwf / pR) ^ 2)
End Function
```



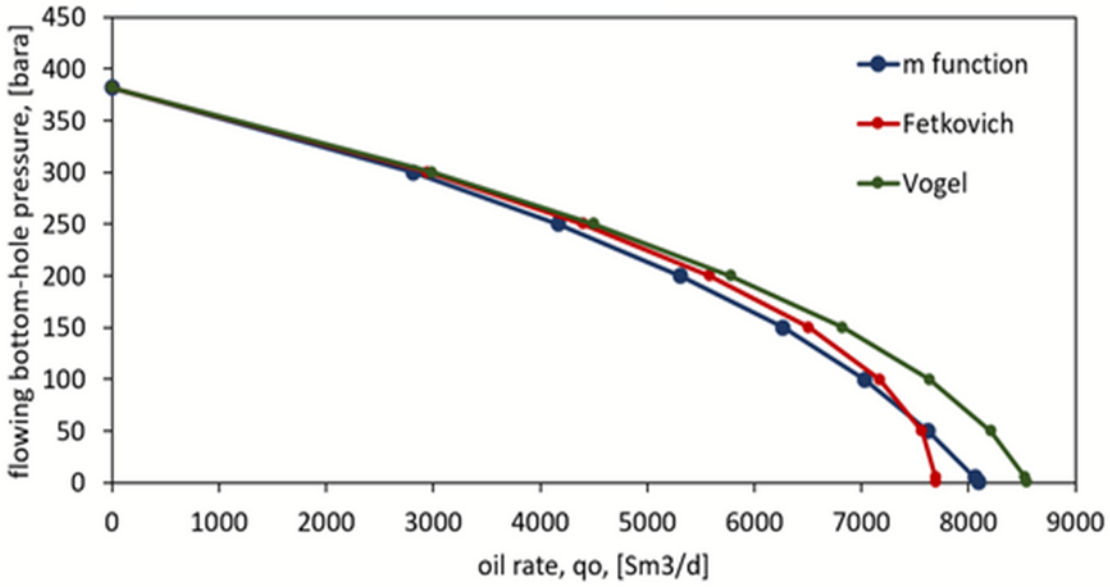
Changing the GOR (Rp) manually to 500 Sm3/Sm3

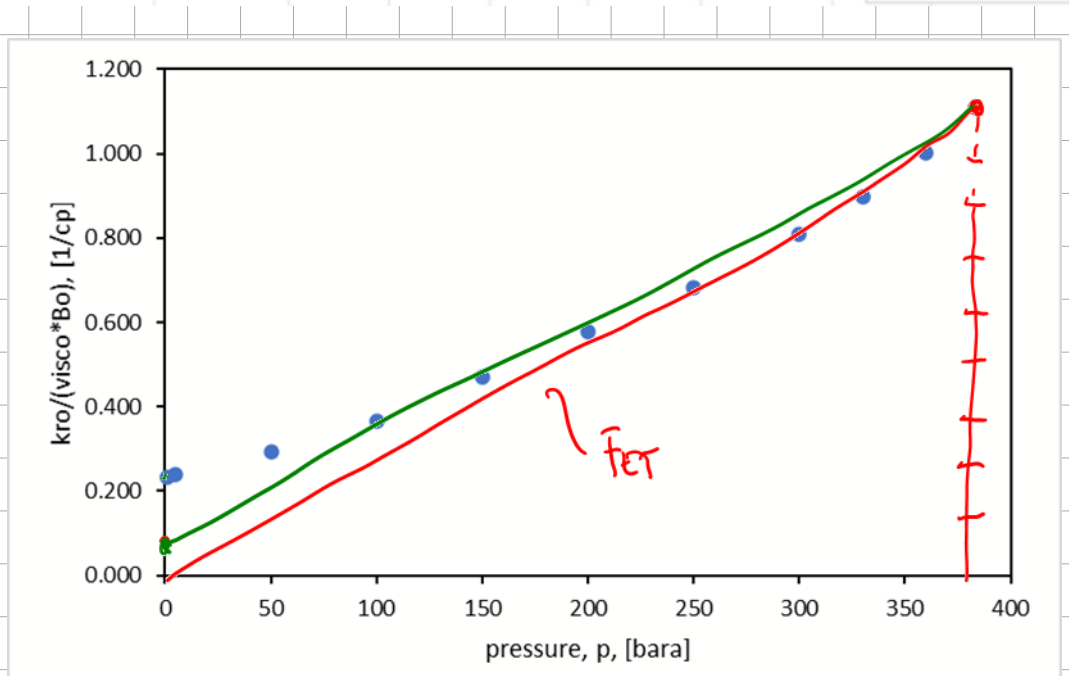


MORE LINEAR....

THE PREDICTION IS BETTER

pwf [bara]	m(p) [bara/cp]	qo [Sm3/d]	qo - Fet [Sm3/d]	qo -Vogel [Sm3/d]	qo - Fet-v2 [Sm3/d]	qo -Vogel-v2 [Sm3/d]
382	222.6	0	0	0		
300	145.3	2810	2950	2990		
250	108.0	4166	4401	4503		
200	76.5	5312	5588	5782		
150	50.2	6268	6511	6826		
100	29.3	7028	7170	7637		
50	12.9	7625	7566	8212		
5	0.9	8059	7697	8530		
1	0.0	8094	7698	8549		





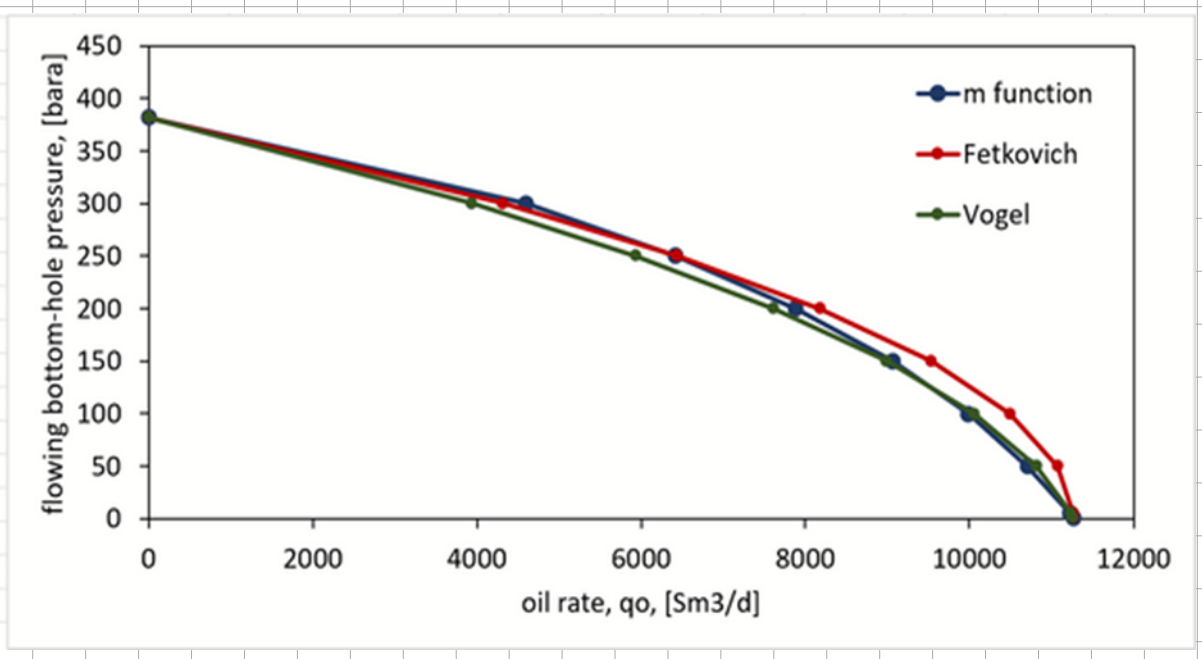
WE CHANGE THE RP BACK TO 300...

But, what if we use the $q_{o max}$ from the m function equation? (11268 Sm^3/d)

$$q_o = q_{o max}\left(1 - \left(\frac{P_{wf}}{P_R}\right)^2\right)$$

$$q_o = q_{o max}\left(1 - 0.2\left(\frac{P_{wf}}{P_R}\right) - 0.8\left(\frac{P_{wf}}{P_R}\right)^2\right)$$

pwf [bara]	m(p) [bara/cp]	qo [Sm3/d]	qo - Fet [Sm3/d]	qo -Vogel [Sm3/d]	qo - Fet-v2 [Sm3/d]	qo -Vogel-v2 [Sm3/d]
382	309.9	0	0	0	0	0
300	183.5	4596	6425	6511	4318	3938
250	133.3	6421	9584	9807	6442	5932
200	93.1	7884	12169	12592	8179	7617
150	60.7	9061	14180	14867	9530	8993
100	35.3	9985	15616	16631	10495	10060
50	15.4	10708	16477	17884	11075	10818
5	1.1	11227	16762	18576	11266	11236
1	0.0	11268	16765	18617	11267	11261



the prediction is improved considerably !!