

Usage: 1) Set values in bold.
 2) Use the Solver with: Set Target cell to \$C\$18 (\$E\$18) Equals to Min By changing cell \$C\$15 (\$E\$15). It is recommended to use the cells in (), which

General Properties	
Temperature (°C)	192
Bed bulk density (kg/m3)	832
Bed expansion	1
Gas density (kg/m3)	0,734
Bed porosity	0,421

Factor by which the bed is expanded; e.g., 1 = no expansion, 1.5 = expanded by a factor 1.5

Gas is Nitrogen. Replace 296.8 by 287 for air and by 462 for water vapor

One can also set Bed porosity if the bulk density is unknown. For that, set E7 to $= (1 - E8 * (1 - E11)) * (E10 - E44) + E44$.

Permeability calculation		
	Coarse interval	Fine interval
d (phi)	6,66	6,62
r.h.s.	2,1429E-01	2,1429E-01
l.h.s.	2,1429E-01	2,1429E-01
difference	3,09E-07	1,51E-07
Permeability (m2)	1,97E-12	2,07E-12

Lower bound of effective size distribution

Right-hand-side of Equ (12)

Left-hand-side of Equ (12)

Upper bound calculations	
Rig diameter (m)	D (phi)
0,14	-1
	0
	1
	2
	3
	4
	5
	6
	7
	8
	9
	10
	11

Constants	
F	0,4
A	242

shape factor $= (b+c)/(2*a)$, Wilson & Huang, 1979
 a, b, c are the longest, middle, and shortest axes of clasts of size d
 constant in MacDonald et al (1991)

Coarse interval										
D (m)	D (phi)	wt%	density (kg/m3)	density*wt	nb clasts	n(D)	D*n(D)	D*D*n(D)	M1	
0,002000	-1	1,9	610	11,59	7,436E+05	8,399E-11	1,680E-13	3,359E-16	2,520E-16	
0,001000	0	2,7	855	23,085	6,031E+06	6,812E-10	6,812E-13	6,812E-16	7,629E-16	
0,000500	1	5,1	1070	54,57	7,282E+07	8,225E-09	4,113E-12	2,056E-15	2,305E-15	
0,000250	2	9,8	1270	124,46	9,432E+08	1,065E-07	2,663E-11	6,658E-15	7,299E-15	

0,000125	3	13,7	1495	204,815	8,961E+09	1,012E-06	1,265E-10	1,581E-14	1,916E-14
0,000063	4	16,3	1525	248,575	8,361E+10	9,444E-06	5,902E-10	3,689E-14	4,683E-14
0,000031	5	16,2	1525	247,05	6,648E+11	7,509E-05	2,346E-09	7,333E-14	1,018E-13
0,000016	6	15,7	1525	239,425	5,154E+12	5,822E-04	9,096E-09	1,421E-13	2,084E-13
0,000008	7	9,6	1525	146,4	2,521E+13	2,848E-03	2,225E-08	1,738E-13	3,388E-13
0,000004	8	4,7	1525	71,675	9,875E+13	1,115E-02	4,357E-08	1,702E-13	4,664E-13
0,000002	9	2,3	1525	35,075	3,866E+14	4,367E-02	8,528E-08	1,666E-13	5,914E-13
0,000001	10	1,4	1525	21,35	1,883E+15	2,126E-01	2,077E-07	2,028E-13	7,434E-13
0,000000	11	0,6	1525	9,15	6,455E+15	7,290E-01	3,560E-07	1,738E-13	8,738E-13
				density avg	sum				
				1437,22	8,85374E+15				

Fine interval (interpolated)

D (m)	D (phi)	nb clasts	n(D)	D*n(D)	D*D*n(D)	M1	M2	M2/M1	Riemann factor
0,002	-1	8,399E-11	1,250E-11	2,500E-14	5,000E-17	3,468E-18	6,937E-21	2,000E-03	0,069370235
0,001866066	-0,9	1,437E-10	2,139E-11	3,991E-14	7,447E-17	8,635E-18	1,658E-20	1,920E-03	
0,001741101	-0,8	2,034E-10	3,027E-11	5,271E-14	9,178E-17	1,500E-17	2,766E-20	1,844E-03	
0,001624505	-0,7	2,631E-10	3,916E-11	6,362E-14	1,034E-16	2,217E-17	3,931E-20	1,773E-03	
0,001515717	-0,6	3,229E-10	4,805E-11	7,283E-14	1,104E-16	2,983E-17	5,092E-20	1,707E-03	
0,001414214	-0,5	3,826E-10	5,694E-11	8,052E-14	1,139E-16	3,773E-17	6,209E-20	1,646E-03	
0,001319508	-0,4	4,423E-10	6,583E-11	8,686E-14	1,146E-16	4,568E-17	7,258E-20	1,589E-03	
0,001231144	-0,3	5,020E-10	7,471E-11	9,198E-14	1,132E-16	5,353E-17	8,225E-20	1,536E-03	
0,001148698	-0,2	5,618E-10	8,360E-11	9,603E-14	1,103E-16	6,119E-17	9,104E-20	1,488E-03	
0,001071773	-0,1	6,215E-10	9,249E-11	9,913E-14	1,062E-16	6,856E-17	9,894E-20	1,443E-03	
0,001	0	6,812E-10	1,014E-10	1,014E-13	1,014E-16	7,559E-17	1,060E-19	1,402E-03	
0,000933033	0,1	1,436E-09	2,137E-10	1,993E-13	1,860E-16	8,849E-17	1,180E-19	1,334E-03	
0,000870551	0,2	2,190E-09	3,259E-10	2,837E-13	2,470E-16	1,056E-16	1,329E-19	1,258E-03	
0,000812252	0,3	2,944E-09	4,382E-10	3,559E-13	2,891E-16	1,257E-16	1,492E-19	1,187E-03	
0,000757858	0,4	3,699E-09	5,505E-10	4,172E-13	3,162E-16	1,476E-16	1,658E-19	1,123E-03	
0,000707107	0,5	4,453E-09	6,627E-10	4,686E-13	3,314E-16	1,706E-16	1,821E-19	1,067E-03	
0,000659754	0,6	5,208E-09	7,750E-10	5,113E-13	3,373E-16	1,940E-16	1,975E-19	1,018E-03	
0,000615572	0,7	5,962E-09	8,873E-10	5,462E-13	3,362E-16	2,173E-16	2,119E-19	9,750E-04	
0,000574349	0,8	6,716E-09	9,996E-10	5,741E-13	3,297E-16	2,402E-16	2,250E-19	9,368E-04	
0,000535887	0,9	7,471E-09	1,112E-09	5,958E-13	3,193E-16	2,624E-16	2,369E-19	9,030E-04	
0,0005	1	8,225E-09	1,224E-09	6,121E-13	3,060E-16	2,836E-16	2,475E-19	8,728E-04	

0,000466516	1,1	1,806E-08	2,687E-09	1,254E-12	5,848E-16	3,241E-16	2,664E-19	8,220E-04
0,000435275	1,2	2,789E-08	4,150E-09	1,806E-12	7,863E-16	3,787E-16	2,902E-19	7,663E-04
0,000406126	1,3	3,772E-08	5,613E-09	2,280E-12	9,258E-16	4,429E-16	3,163E-19	7,140E-04
0,000378929	1,4	4,755E-08	7,076E-09	2,681E-12	1,016E-15	5,134E-16	3,430E-19	6,680E-04
0,000353553	1,5	5,738E-08	8,539E-09	3,019E-12	1,067E-15	5,875E-16	3,692E-19	6,284E-04
0,000329877	1,6	6,721E-08	1,000E-08	3,300E-12	1,088E-15	6,630E-16	3,941E-19	5,944E-04
0,000307786	1,7	7,704E-08	1,147E-08	3,529E-12	1,086E-15	7,383E-16	4,173E-19	5,651E-04
0,000287175	1,8	8,687E-08	1,293E-08	3,713E-12	1,066E-15	8,123E-16	4,385E-19	5,398E-04
0,000267943	1,9	9,670E-08	1,439E-08	3,856E-12	1,033E-15	8,839E-16	4,577E-19	5,178E-04
0,00025	2	1,065E-07	1,585E-08	3,964E-12	9,909E-16	9,527E-16	4,749E-19	4,985E-04
0,000233258	2,1	1,971E-07	2,933E-08	6,842E-12	1,596E-15	1,063E-15	5,007E-19	4,709E-04
0,000217638	2,2	2,876E-07	4,281E-08	9,317E-12	2,028E-15	1,204E-15	5,313E-19	4,413E-04
0,000203063	2,3	3,782E-07	5,629E-08	1,143E-11	2,321E-15	1,365E-15	5,640E-19	4,132E-04
0,000189465	2,4	4,688E-07	6,976E-08	1,322E-11	2,504E-15	1,539E-15	5,969E-19	3,879E-04
0,000176777	2,5	5,593E-07	8,324E-08	1,471E-11	2,601E-15	1,719E-15	6,288E-19	3,658E-04
0,000164938	2,6	6,499E-07	9,672E-08	1,595E-11	2,631E-15	1,902E-15	6,589E-19	3,465E-04
0,000153893	2,7	7,404E-07	1,102E-07	1,696E-11	2,610E-15	2,083E-15	6,868E-19	3,297E-04
0,000143587	2,8	8,310E-07	1,237E-07	1,776E-11	2,550E-15	2,260E-15	7,122E-19	3,152E-04
0,000133972	2,9	9,215E-07	1,371E-07	1,837E-11	2,462E-15	2,430E-15	7,351E-19	3,024E-04
0,000125	3	1,012E-06	1,506E-07	1,883E-11	2,354E-15	2,594E-15	7,555E-19	2,913E-04
0,000116629	3,1	1,855E-06	2,761E-07	3,220E-11	3,756E-15	2,854E-15	7,859E-19	2,753E-04
0,000108819	3,2	2,698E-06	4,016E-07	4,370E-11	4,756E-15	3,184E-15	8,218E-19	2,581E-04
0,000101532	3,3	3,542E-06	5,271E-07	5,352E-11	5,433E-15	3,561E-15	8,600E-19	2,415E-04
9,47323E-05	3,4	4,385E-06	6,526E-07	6,182E-11	5,856E-15	3,967E-15	8,985E-19	2,265E-04
8,83883E-05	3,5	5,228E-06	7,781E-07	6,877E-11	6,079E-15	4,389E-15	9,358E-19	2,132E-04
8,24692E-05	3,6	6,071E-06	9,035E-07	7,451E-11	6,145E-15	4,815E-15	9,709E-19	2,016E-04
7,69465E-05	3,7	6,914E-06	1,029E-06	7,918E-11	6,093E-15	5,238E-15	1,003E-18	1,916E-04
7,17936E-05	3,8	7,758E-06	1,155E-06	8,289E-11	5,951E-15	5,651E-15	1,033E-18	1,828E-04
6,69858E-05	3,9	8,601E-06	1,280E-06	8,574E-11	5,743E-15	6,049E-15	1,060E-18	1,752E-04
0,0000625	4	9,444E-06	1,405E-06	8,784E-11	5,490E-15	6,430E-15	1,084E-18	1,685E-04
5,83146E-05	4,1	1,601E-05	2,382E-06	1,389E-10	8,102E-15	6,992E-15	1,116E-18	1,597E-04
5,44094E-05	4,2	2,257E-05	3,359E-06	1,828E-10	9,945E-15	7,682E-15	1,154E-18	1,502E-04
5,07658E-05	4,3	2,914E-05	4,336E-06	2,201E-10	1,118E-14	8,457E-15	1,193E-18	1,411E-04
4,73661E-05	4,4	3,570E-05	5,313E-06	2,517E-10	1,192E-14	9,284E-15	1,232E-18	1,327E-04
4,41942E-05	4,5	4,227E-05	6,290E-06	2,780E-10	1,229E-14	1,014E-14	1,270E-18	1,253E-04
4,12346E-05	4,6	4,883E-05	7,267E-06	2,997E-10	1,236E-14	1,099E-14	1,305E-18	1,187E-04

3,84733E-05	4,7	5,539E-05	8,244E-06	3,172E-10	1,220E-14	1,184E-14	1,338E-18	1,130E-04
3,58968E-05	4,8	6,196E-05	9,221E-06	3,310E-10	1,188E-14	1,266E-14	1,368E-18	1,080E-04
3,34929E-05	4,9	6,852E-05	1,020E-05	3,416E-10	1,144E-14	1,346E-14	1,394E-18	1,036E-04
0,00003125	5	7,509E-05	1,117E-05	3,492E-10	1,091E-14	1,421E-14	1,418E-18	9,974E-05
2,91573E-05	5,1	1,258E-04	1,872E-05	5,459E-10	1,592E-14	1,532E-14	1,450E-18	9,466E-05
2,72047E-05	5,2	1,765E-04	2,627E-05	7,146E-10	1,944E-14	1,667E-14	1,487E-18	8,920E-05
2,53829E-05	5,3	2,272E-04	3,381E-05	8,583E-10	2,179E-14	1,818E-14	1,525E-18	8,389E-05
2,36831E-05	5,4	2,779E-04	4,136E-05	9,795E-10	2,320E-14	1,979E-14	1,563E-18	7,900E-05
2,20971E-05	5,5	3,286E-04	4,891E-05	1,081E-09	2,388E-14	2,144E-14	1,600E-18	7,460E-05
2,06173E-05	5,6	3,793E-04	5,645E-05	1,164E-09	2,400E-14	2,311E-14	1,634E-18	7,071E-05
1,92366E-05	5,7	4,300E-04	6,400E-05	1,231E-09	2,368E-14	2,475E-14	1,666E-18	6,730E-05
1,79484E-05	5,8	4,807E-04	7,155E-05	1,284E-09	2,305E-14	2,635E-14	1,694E-18	6,430E-05
1,67465E-05	5,9	5,315E-04	7,909E-05	1,325E-09	2,218E-14	2,789E-14	1,720E-18	6,168E-05
0,000015625	6	5,822E-04	8,664E-05	1,354E-09	2,115E-14	2,936E-14	1,743E-18	5,938E-05
1,45786E-05	6,1	8,087E-04	1,204E-04	1,755E-09	2,558E-14	3,113E-14	1,769E-18	5,682E-05
1,36024E-05	6,2	1,035E-03	1,541E-04	2,096E-09	2,851E-14	3,311E-14	1,796E-18	5,424E-05
1,26914E-05	6,3	1,262E-03	1,878E-04	2,383E-09	3,025E-14	3,521E-14	1,822E-18	5,176E-05
1,18415E-05	6,4	1,488E-03	2,215E-04	2,623E-09	3,106E-14	3,736E-14	1,848E-18	4,946E-05
1,10485E-05	6,5	1,715E-03	2,552E-04	2,820E-09	3,116E-14	3,952E-14	1,872E-18	4,736E-05
1,03087E-05	6,6	1,942E-03	2,889E-04	2,979E-09	3,071E-14	4,165E-14	1,894E-18	4,547E-05
9,61832E-06	6,7	2,168E-03	3,227E-04	3,103E-09	2,985E-14	4,372E-14	1,914E-18	4,377E-05
8,97421E-06	6,8	2,395E-03	3,564E-04	3,198E-09	2,870E-14	4,572E-14	1,932E-18	4,225E-05
8,37323E-06	6,9	2,621E-03	3,901E-04	3,266E-09	2,735E-14	4,761E-14	1,948E-18	4,090E-05
7,8125E-06	7	2,848E-03	4,238E-04	3,311E-09	2,587E-14	4,941E-14	1,962E-18	3,970E-05
7,28932E-06	7,1	3,678E-03	5,474E-04	3,990E-09	2,909E-14	5,142E-14	1,976E-18	3,843E-05
6,80118E-06	7,2	4,509E-03	6,710E-04	4,564E-09	3,104E-14	5,358E-14	1,991E-18	3,716E-05
6,34572E-06	7,3	5,340E-03	7,947E-04	5,043E-09	3,200E-14	5,580E-14	2,005E-18	3,593E-05
5,92077E-06	7,4	6,170E-03	9,183E-04	5,437E-09	3,219E-14	5,803E-14	2,018E-18	3,478E-05
5,52427E-06	7,5	7,001E-03	1,042E-03	5,756E-09	3,180E-14	6,024E-14	2,030E-18	3,371E-05
5,15433E-06	7,6	7,831E-03	1,165E-03	6,007E-09	3,096E-14	6,238E-14	2,041E-18	3,272E-05
4,80916E-06	7,7	8,662E-03	1,289E-03	6,200E-09	2,981E-14	6,445E-14	2,051E-18	3,183E-05
4,4871E-06	7,8	9,493E-03	1,413E-03	6,339E-09	2,844E-14	6,643E-14	2,060E-18	3,102E-05
4,18662E-06	7,9	1,032E-02	1,536E-03	6,432E-09	2,693E-14	6,829E-14	2,068E-18	3,028E-05
3,90625E-06	8	1,115E-02	1,660E-03	6,484E-09	2,533E-14	7,005E-14	2,075E-18	2,962E-05
3,64466E-06	8,1	1,441E-02	2,144E-03	7,813E-09	2,848E-14	7,203E-14	2,082E-18	2,891E-05
3,40059E-06	8,2	1,766E-02	2,628E-03	8,936E-09	3,039E-14	7,413E-14	2,089E-18	2,818E-05

3,17286E-06	8,3	2,091E-02	3,112E-03	9,872E-09	3,132E-14	7,631E-14	2,096E-18	2,747E-05
2,96038E-06	8,4	2,416E-02	3,595E-03	1,064E-08	3,151E-14	7,849E-14	2,103E-18	2,679E-05
2,76214E-06	8,5	2,741E-02	4,079E-03	1,127E-08	3,112E-14	8,065E-14	2,109E-18	2,614E-05
2,57716E-06	8,6	3,066E-02	4,563E-03	1,176E-08	3,031E-14	8,275E-14	2,114E-18	2,555E-05
2,40458E-06	8,7	3,391E-02	5,047E-03	1,214E-08	2,918E-14	8,478E-14	2,119E-18	2,499E-05
2,24355E-06	8,8	3,716E-02	5,531E-03	1,241E-08	2,784E-14	8,671E-14	2,123E-18	2,449E-05
2,09331E-06	8,9	4,041E-02	6,015E-03	1,259E-08	2,636E-14	8,854E-14	2,127E-18	2,402E-05
1,95313E-06	9	4,367E-02	6,499E-03	1,269E-08	2,479E-14	9,026E-14	2,130E-18	2,360E-05
1,82233E-06	9,1	6,056E-02	9,013E-03	1,642E-08	2,993E-14	9,233E-14	2,134E-18	2,311E-05
1,70029E-06	9,2	7,746E-02	1,153E-02	1,960E-08	3,333E-14	9,465E-14	2,138E-18	2,259E-05
1,58643E-06	9,3	9,436E-02	1,404E-02	2,228E-08	3,534E-14	9,710E-14	2,142E-18	2,206E-05
1,48019E-06	9,4	1,113E-01	1,656E-02	2,451E-08	3,628E-14	9,961E-14	2,146E-18	2,154E-05
1,38107E-06	9,5	1,281E-01	1,907E-02	2,634E-08	3,638E-14	1,021E-13	2,149E-18	2,104E-05
1,28858E-06	9,6	1,450E-01	2,159E-02	2,782E-08	3,584E-14	1,046E-13	2,152E-18	2,057E-05
1,20229E-06	9,7	1,619E-01	2,410E-02	2,898E-08	3,484E-14	1,070E-13	2,155E-18	2,014E-05
1,12178E-06	9,8	1,788E-01	2,662E-02	2,986E-08	3,349E-14	1,094E-13	2,158E-18	1,973E-05
1,04665E-06	9,9	1,957E-01	2,913E-02	3,049E-08	3,191E-14	1,116E-13	2,160E-18	1,936E-05
9,76563E-07	10	2,126E-01	3,164E-02	3,090E-08	3,018E-14	1,137E-13	2,162E-18	1,902E-05
9,11165E-07	10,1	2,643E-01	3,933E-02	3,584E-08	3,265E-14	1,159E-13	2,164E-18	1,867E-05
8,50147E-07	10,2	3,159E-01	4,702E-02	3,997E-08	3,398E-14	1,183E-13	2,166E-18	1,831E-05
7,93215E-07	10,3	3,676E-01	5,470E-02	4,339E-08	3,442E-14	1,207E-13	2,168E-18	1,797E-05
7,40096E-07	10,4	4,192E-01	6,239E-02	4,617E-08	3,417E-14	1,231E-13	2,170E-18	1,764E-05
6,90534E-07	10,5	4,708E-01	7,007E-02	4,839E-08	3,341E-14	1,254E-13	2,172E-18	1,732E-05
6,44291E-07	10,6	5,225E-01	7,776E-02	5,010E-08	3,228E-14	1,276E-13	2,173E-18	1,703E-05
6,01145E-07	10,7	5,741E-01	8,544E-02	5,136E-08	3,088E-14	1,298E-13	2,174E-18	1,676E-05
5,60888E-07	10,8	6,258E-01	9,313E-02	5,223E-08	2,930E-14	1,318E-13	2,176E-18	1,651E-05
5,23327E-07	10,9	6,774E-01	1,008E-01	5,276E-08	2,761E-14	1,337E-13	2,177E-18	1,628E-05
4,88281E-07	11	7,290E-01	1,085E-01	5,298E-08	2,587E-14	1,355E-13	2,177E-18	1,607E-05

sum

6,719E+00

h are for Fine interpolated intervals

w min-frict (wt% w min-vol (wt%)	
0,70	41,85
0,49	55,96
0,31	64,93
0,18	67,27
0,11	65,49
0,05	50,50
0,03	34,30
0,01	18,60
0,01	9,00
0,00	4,30
0,00	2,00
0,00	0,60
0,00	0,60

Minimum amount of clasts that could affect permeability

M2	M2/M1	wt/density
5,039E-19	2,000E-03	3,115E-03
1,015E-18	1,330E-03	3,158E-03
1,786E-18	7,748E-04	4,766E-03
3,034E-18	4,157E-04	7,717E-03

4,517E-18	2,358E-04	9,164E-03
6,246E-18	1,334E-04	1,069E-02
7,965E-18	7,822E-05	1,062E-02
9,630E-18	4,621E-05	1,030E-02
1,065E-17	3,143E-05	6,295E-03
1,115E-17	2,390E-05	3,082E-03
1,139E-17	1,926E-05	1,508E-03
1,154E-17	1,552E-05	9,180E-04
1,160E-17	1,328E-05	3,934E-04







