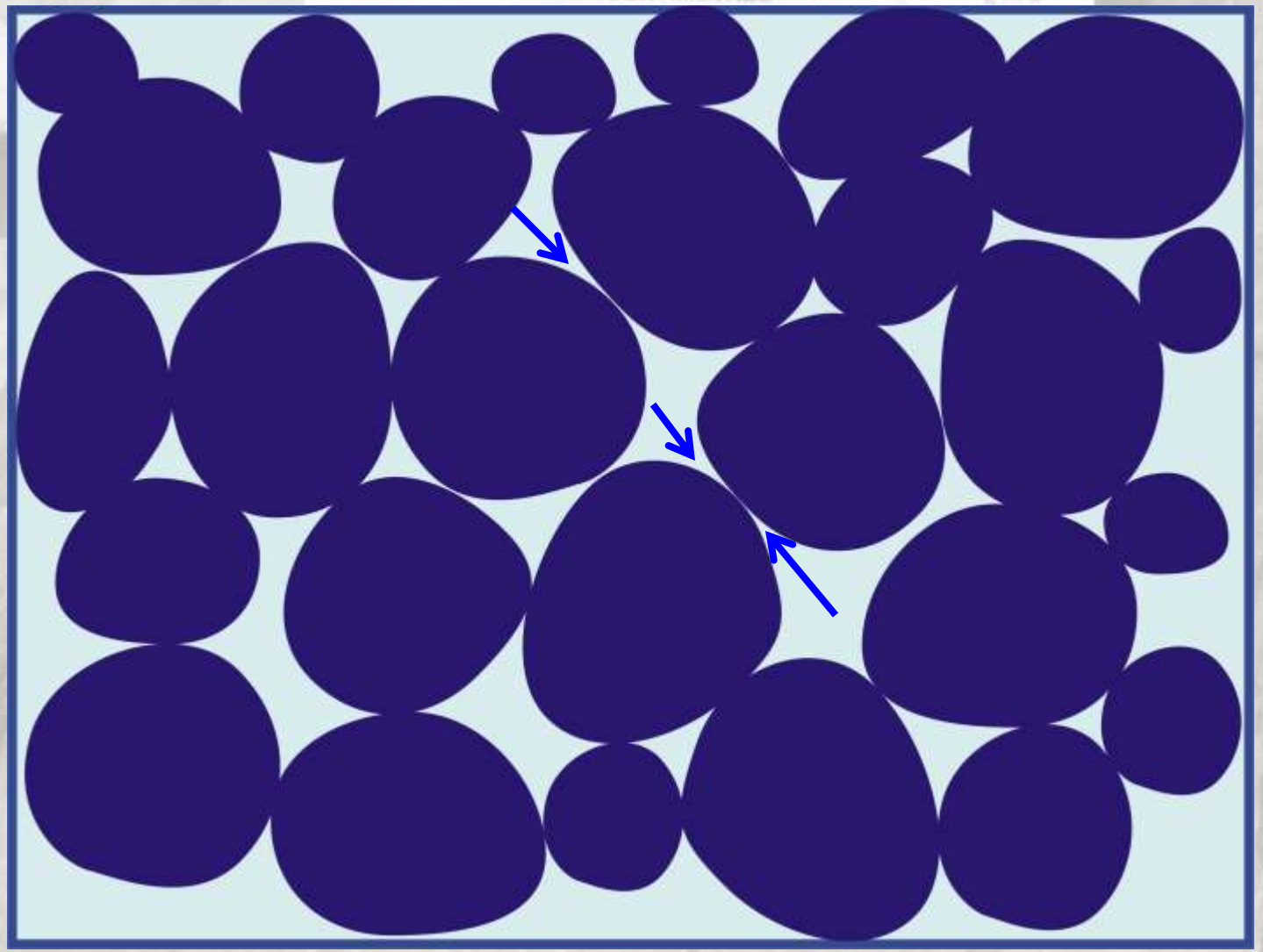

INCHES
CENTIMETRES
ACWADAM
1.11
DIP DIRECTION
25°
DIP (FOLIATION)
40°
N
2009 6 27

# Groundwater movement has similarities…

- Ability of material to allow flow of heat is called THERMAL CONDUCTIVITY.
- Ability of material to allow flow of electricity is called ELECTRICAL CONDUCTIVITY.
- Ability of material to allow flow of groundwater is called HYDRAULIC CONDUCTIVITY.

# “Interconnectedness”

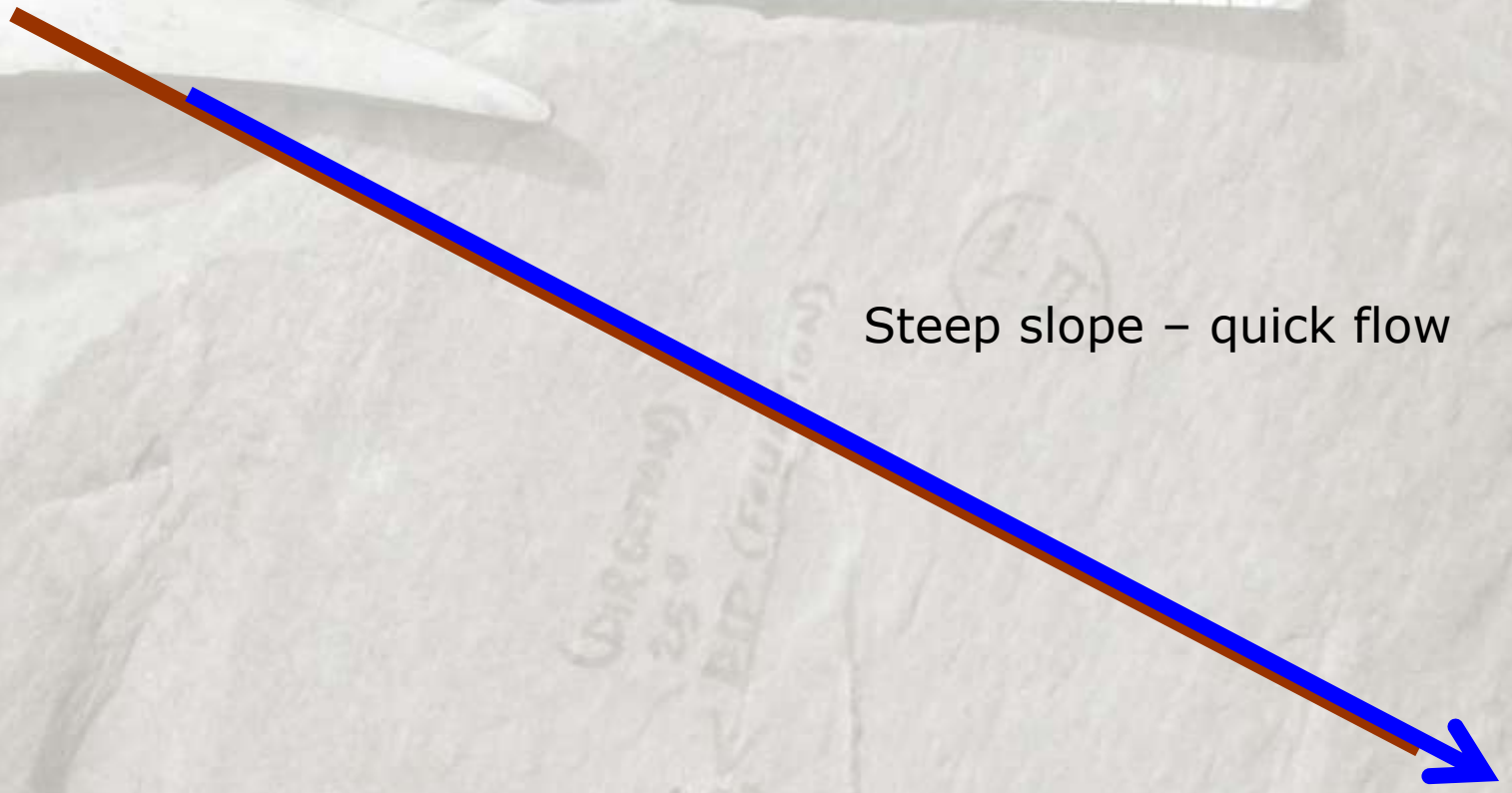


# What is hydraulic conductivity?

A rock with good hydraulic conductivity allows groundwater to easily flow through it.

A rock with poor hydraulic conductivity does not allow easy movement of groundwater.

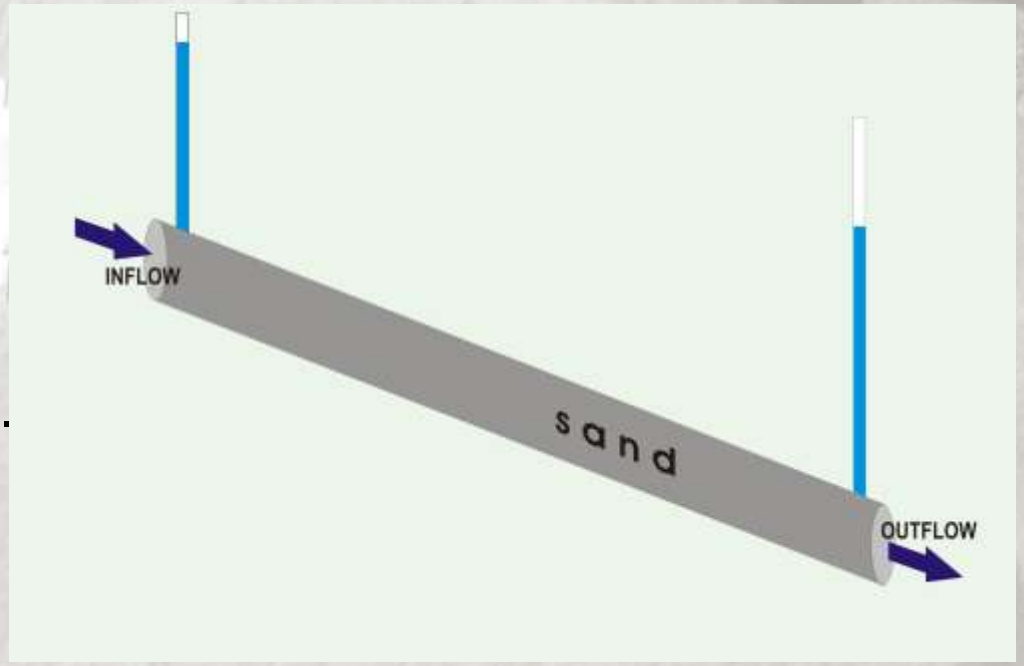
# Water flow on land surface...



Steep slope – quick flow

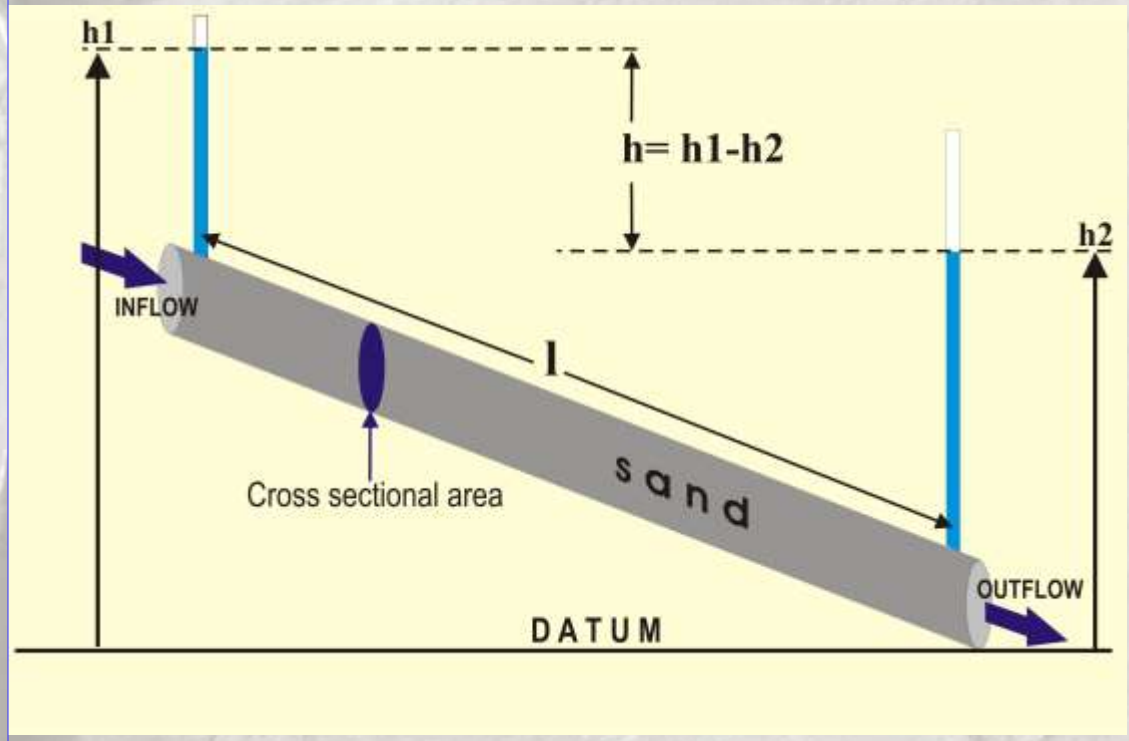
Gentle slope – slow flow

# Darcy's apparatus




- Henry Darcy, a Frenchman, studied the flow of water through porous sand in 1856.
- The experiment consisted of the *Darcy apparatus:*
  - A glass cylinder filled with porous sand.
  - The glass cylinder with the sand bed had an inlet for inflow of water and an outlet for outflow of water.
  - Two vertical glass tubes (manometers) fitted in the sand tube placed at a fixed distance from each other to measure the respective levels (hydraulic heads).

# Darcy's experiment

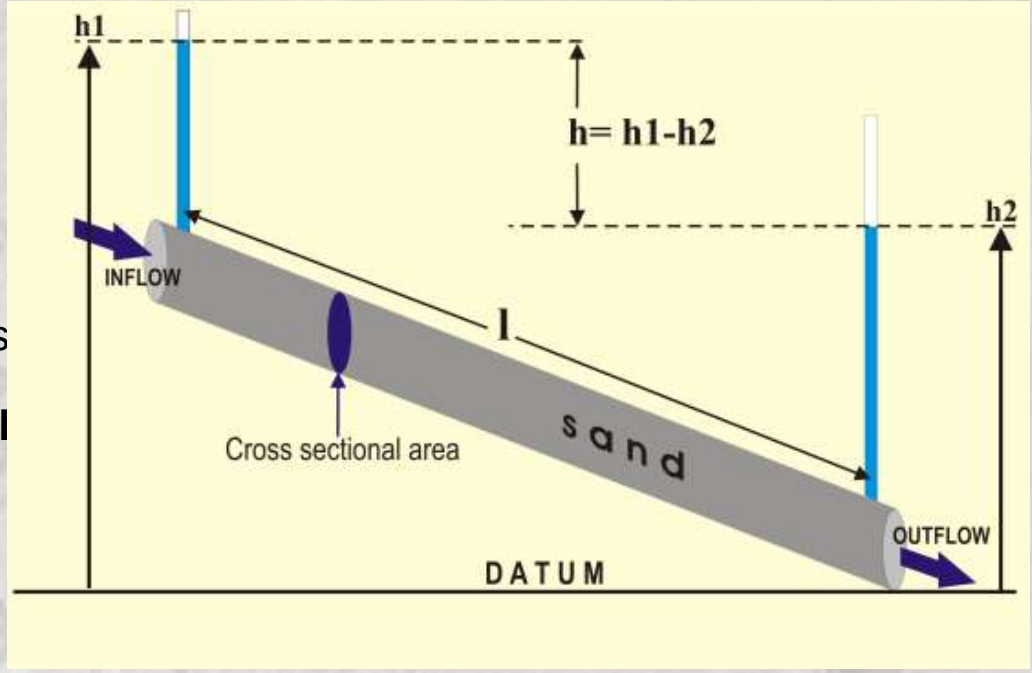



- Measurement of height to which the water rises in the two manometer tubes after water is passed through the sand from the inlet.
- The vertical difference in the water levels (hydraulic head) in the tubes– "h".
- The distance between the two points (i.e. the two tubes)– "l".

# Darcy's law

- The rate of flow of water through the porous sand bed is directly proportional to the hydraulic head difference (h) between the two points and inversely proportional to the distance between the two points (l).
- i.e. $v \propto h/l$
- To make this into an equation,

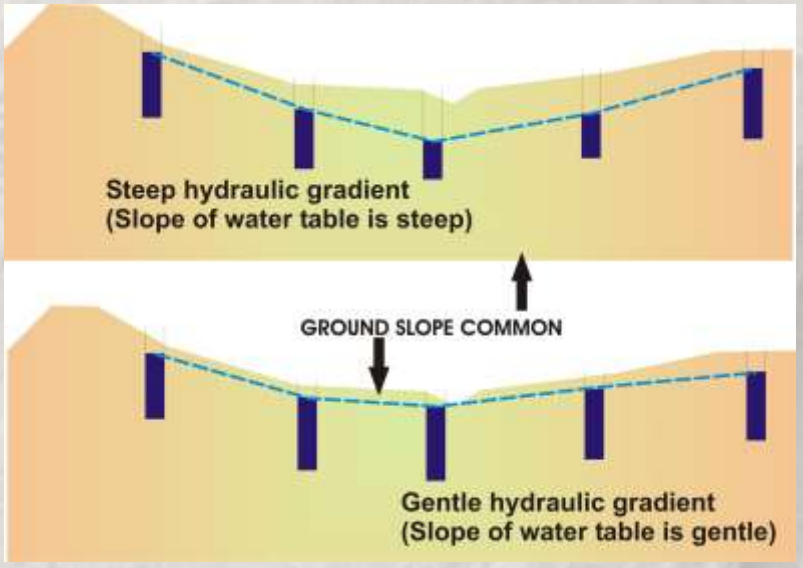
  $v = k(h/l)$
  - v= velocity of water
  - h= hydraulic head difference between the two points.
  - l= distance between the two points
  - **k is the coefficient of permeability, now more popularly called HYDRAULIC CONDUCTIVITY.**



# Hydraulic gradient

- Gradient means slope.
- The hydraulic head (commonly called ‘head’ of water/groundwater) is the ability of water to raise itself upto a certain height from a standard datum (say mean sea level or MSL).
- It becomes easy now to note that the difference of hydraulic head **h** over the distance **l** is nothing but the slope of the imaginary line joining the heads in the tube.
- **In other words it is the slope of the water level surface, called *hydraulic gradient* i.**

**v= k(h/l)= ki**



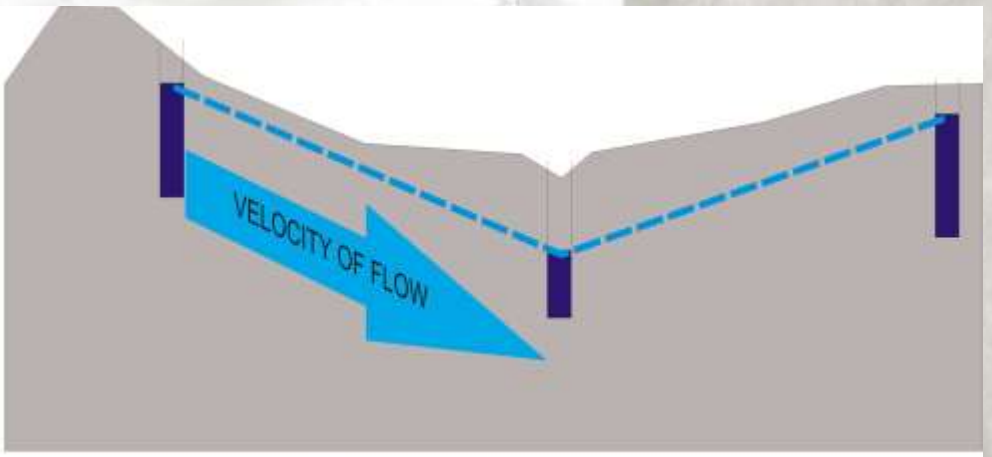

**Therefore, v= ki**

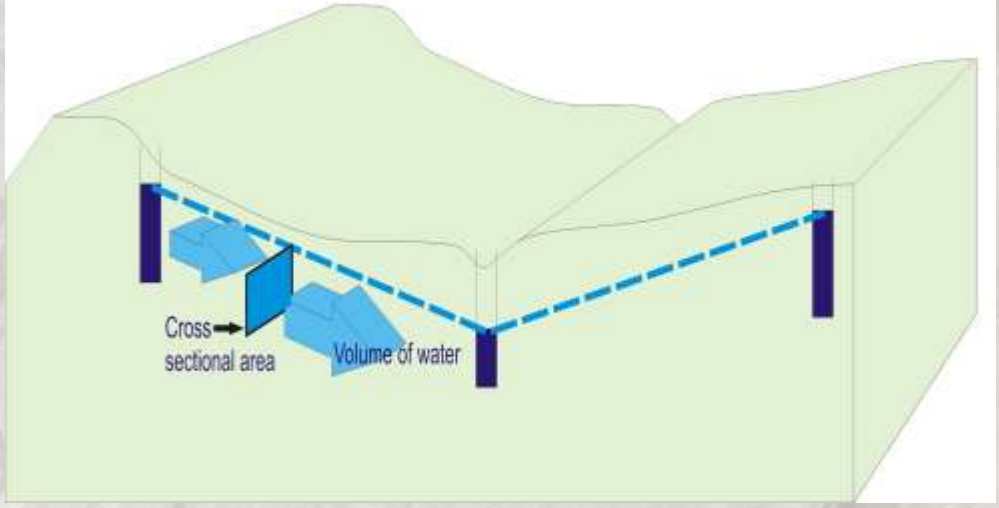
# Quantity of water groundwater flow

Generally, one is interested more in the QUANTITY of groundwater flow rather than its velocity.

- Velocity is measured over a distance.
- Quantity can be measured as flow through a unit area.

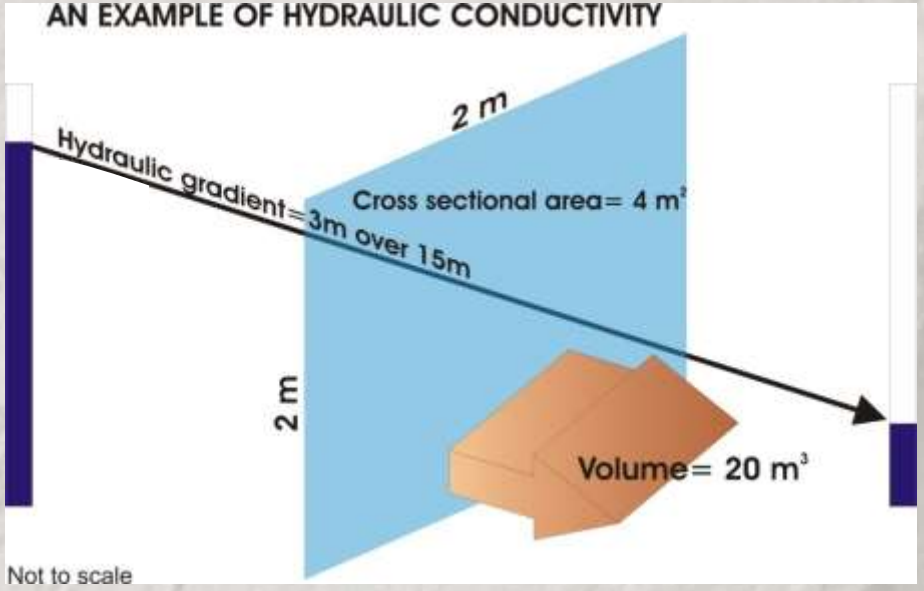
Darcy's law can be further expanded to take this into account.



# Darcy's law in context of quantity of water flow

- Q= quantity of water (in $m^3$) flowing through…
- …a unit cross sectional area A (in $m^2$)
- v= velocity of water flow (in m/min)
  - Q= A x v (but v= ki)
  - Q= A x ki
  - **Q= kiA** or
  - **k= Q/iA**



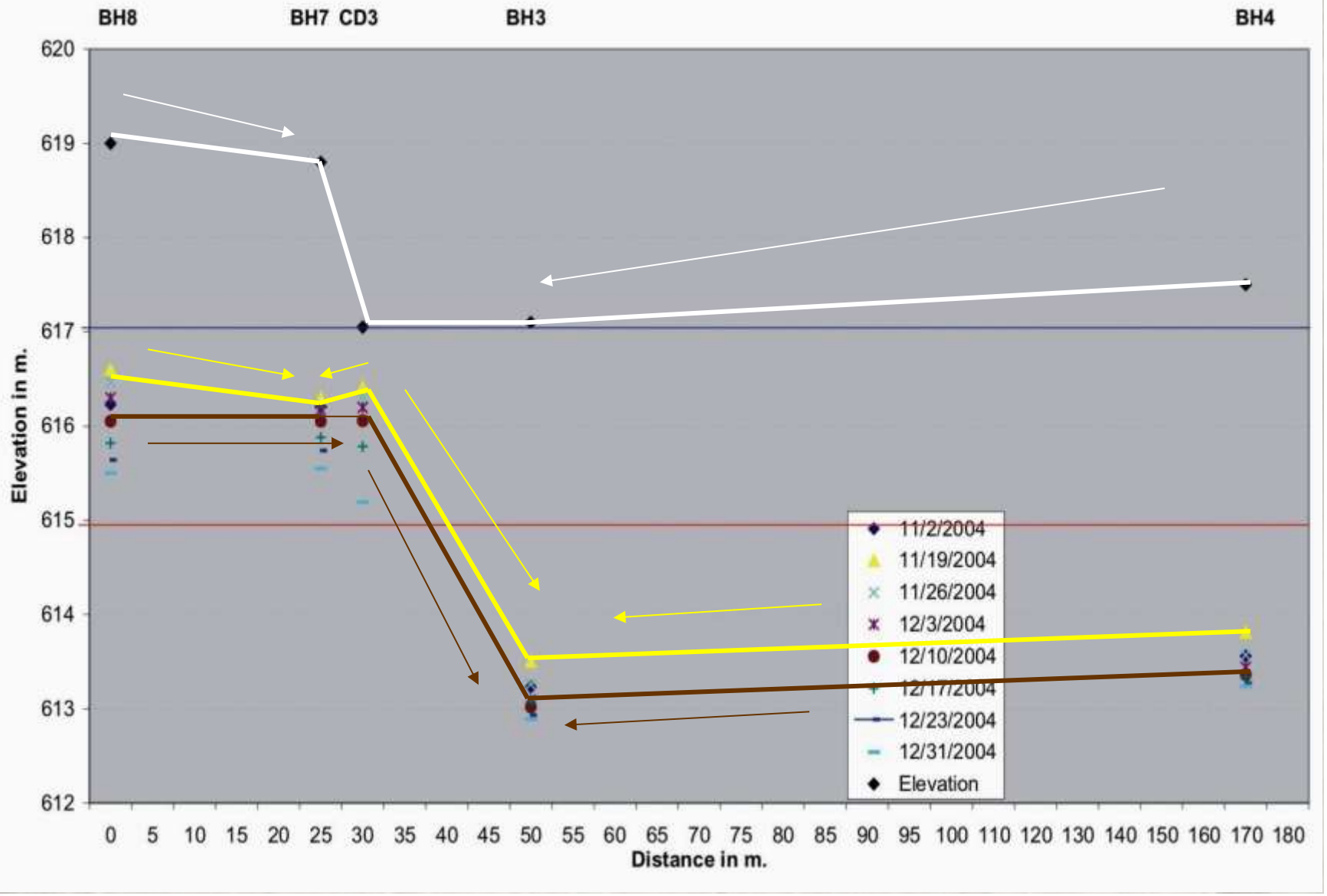

Q= 20 $m^3$/day; A= 4 $m^2$; i= 0.2
Hydraulic conductivity k= 20/(0.2x4)
**k= 25 m/day**

**Hydraulic conductivity k is measured in m/sec or m/min or m/day**

# How does this relate to the movement of groundwater in the field

- Darcy found out that the velocity of water (v) in porous medium is directly proportional to the hydraulic gradient (i).
- In a porous zone of saturation, groundwater moves along the hydraulic gradient.
- This hydraulic gradient is a practical manifestation of the slope of the water table.
- This slope is nothing but the difference in the elevation of the water table (h) in any two wells spaced at a distance of ‘l’ from each other.

# Hydraulic gradient: cross section across a stream




Kolwan valley case study (ACWADAM)- AGRAR project

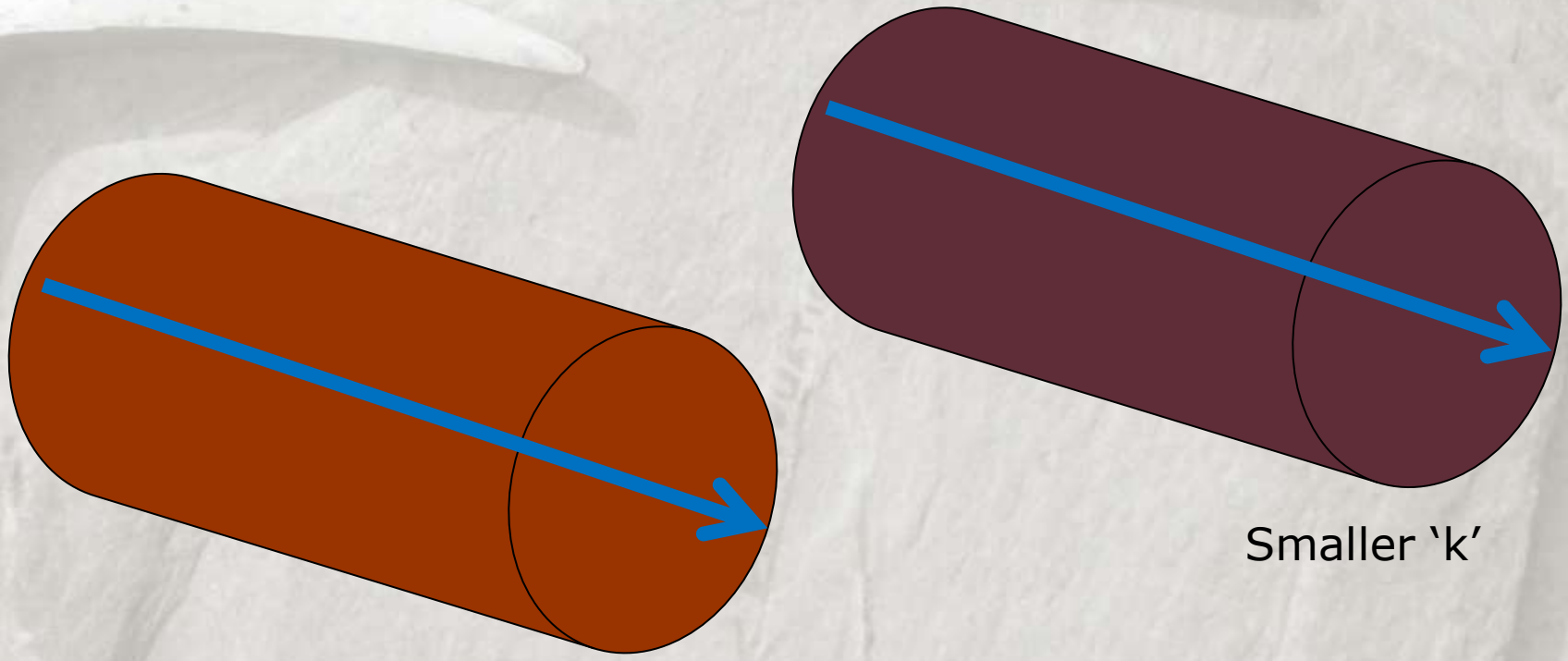
# Hydraulic conductivity of unconsolidated sediments

| Sediment type | Size in mm | k in m/day |
|---|---|---|
| Clay | <0.004 to 0.1 | 0.08 to 0.1 |
| Sand | 0.1 to 0.2 | 1 to 100 |
| Gravel | 2 to 20 | 100 to 1000 |

The aperture of pores, i.e. their "interconnection" increases along with the hydraulic conductivity as grain size increases.

In fine grained sediments, the aperture of pores is small, reducing the cross sectional area through which groundwater can flow - this means a lower hydraulic conductivity.

# Rate of groundwater flow depends upon hydraulic conductivity



Smaller ‘k’

Greater ‘k’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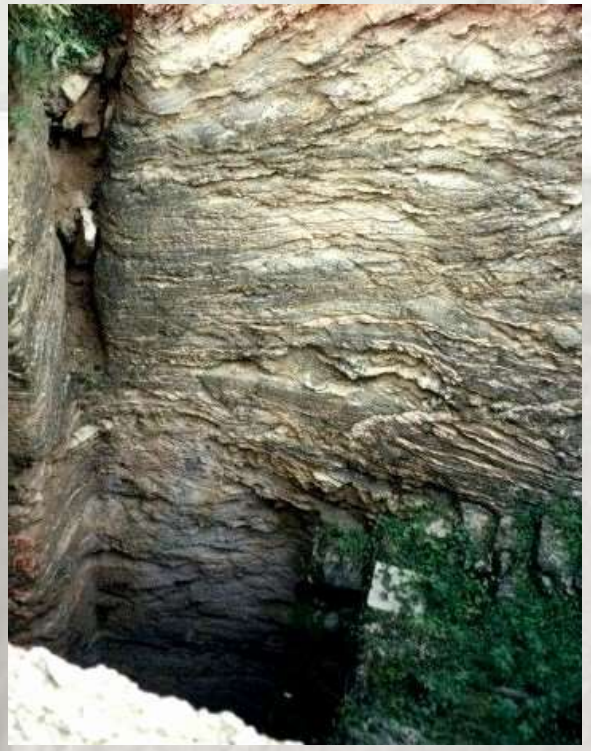
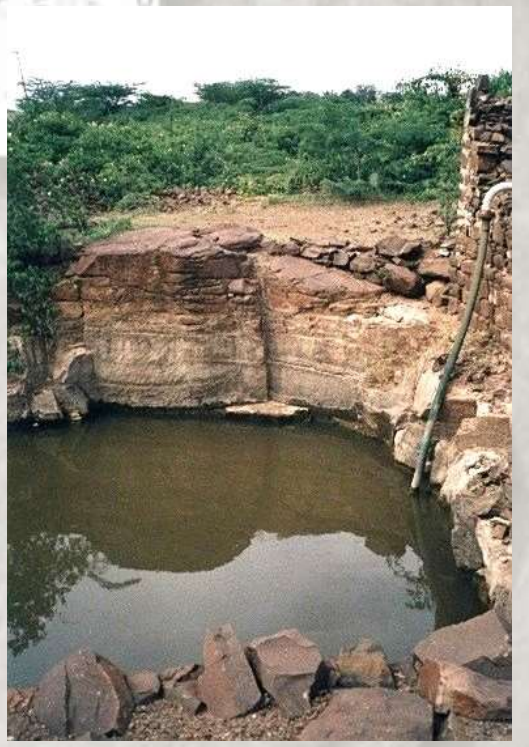
# Hydraulic conductivity: sediments & sedimentary rocks

# Hydraulic conductivity in a well tapping hard rocks





# Finally,

In hydrogeology, the hydrologic properties of rocks (openings) signify the status of a rock to act as a good or poor aquifer.

…these properties decide whether a rock can store and transmit groundwater.

The status of a rock with regards to groundwater occurrence and movement is decided by its porosity (specific yield, more practically) and its hydraulic conductivity.

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