OCCURRENCE AND MOVEMENT OF GROUNDWATER
Water Bearing Properties of Rocks and Sediments

Groundwater is the subsurface water that occurs beneath the water table in soils and geologic formations that are fully saturated.

CLASSIFICATION OF FORMATIONS INTO HYDROGEOLOGIC UNITS

Aquifer is a geologic formation, or a group of formations, or part of a formation that is capable of storing and transmitting significant quantities of water under ordinary field conditions.

Sandstone, conglomerate, fractured limestone and unconsolidated sand and gravel are the formations showing good aquifer properties.

Fractured volcanic rocks, rubble zones between volcanic flows, fractured granite and schist.

Aquiclude is a geologic formation which contains water but is incapable of transmitting significant quantities of water under ordinary field conditions such as saturated clay layer.

Aquitard is a geologic formation which is permeable enough to transmit water in quantities that are significant in the study of regional groundwater flow, but their permeability is not sufficient to allow the completion of production wells within them (semi-pervious or leaky formations) siltstone or sandy silt.

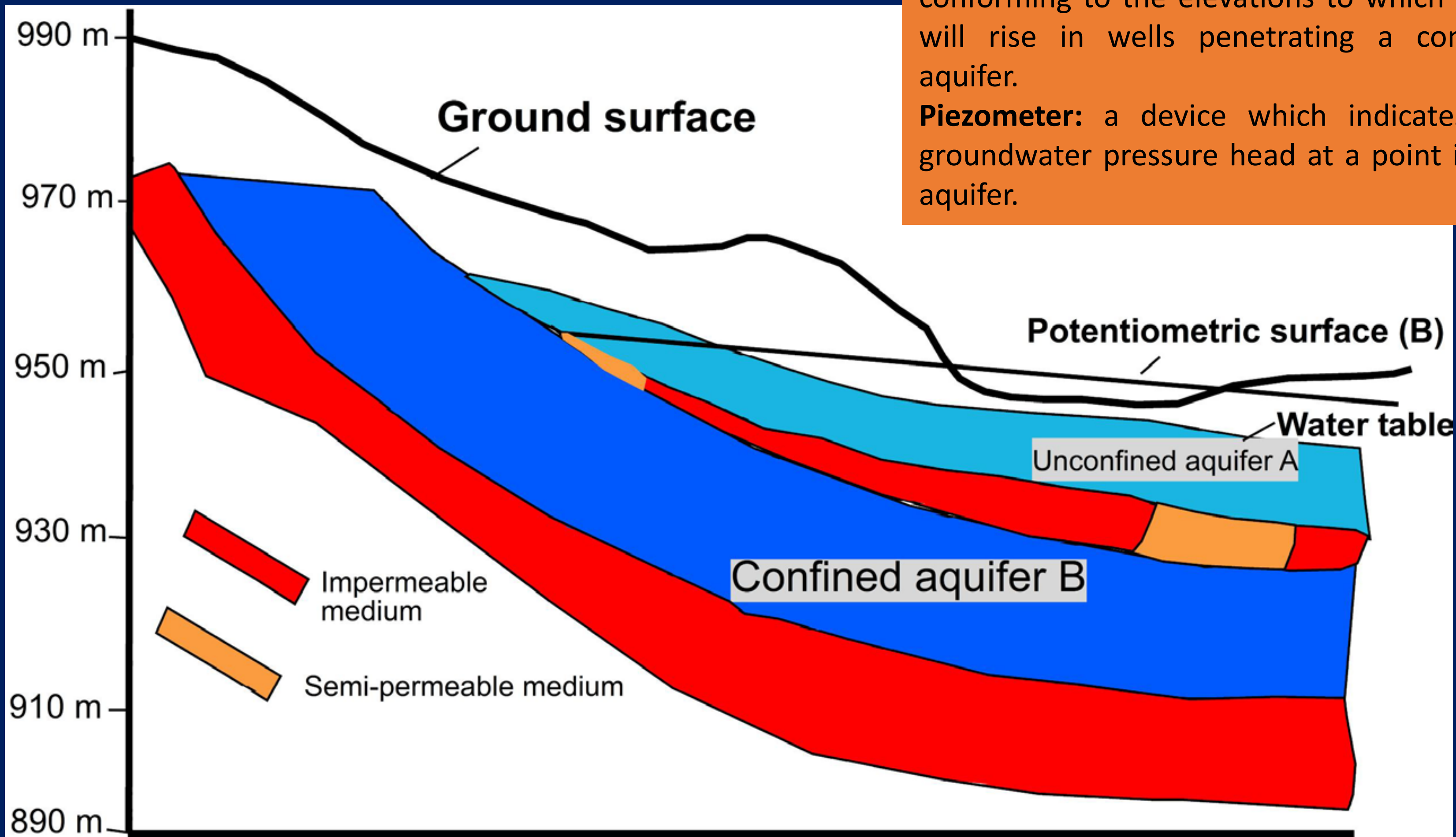
Aquifuge is an impervious formation which neither contains nor transmits water such as unfractured granite.

Types of Aquifers

A. Unconfined (water table aquifer, phreatic aquifer) aquifer is one in which the water table forms the upper boundary where groundwater pressures are equal to atmospheric pressure.

B. Confined aquifer is one that is confined between two impervious or semi-pervious formations (aquicludes or aquitards)

Piezometric surface: The imaginary surface, conforming to the elevations to which water will rise in wells penetrating a confined aquifer.
Piezometer: a device which indicates the groundwater pressure head at a point in the aquifer.



C. Leaky Aquifer whether confined or unconfined, they can lose or gain water through either or both of the formations bounding them from above or below.

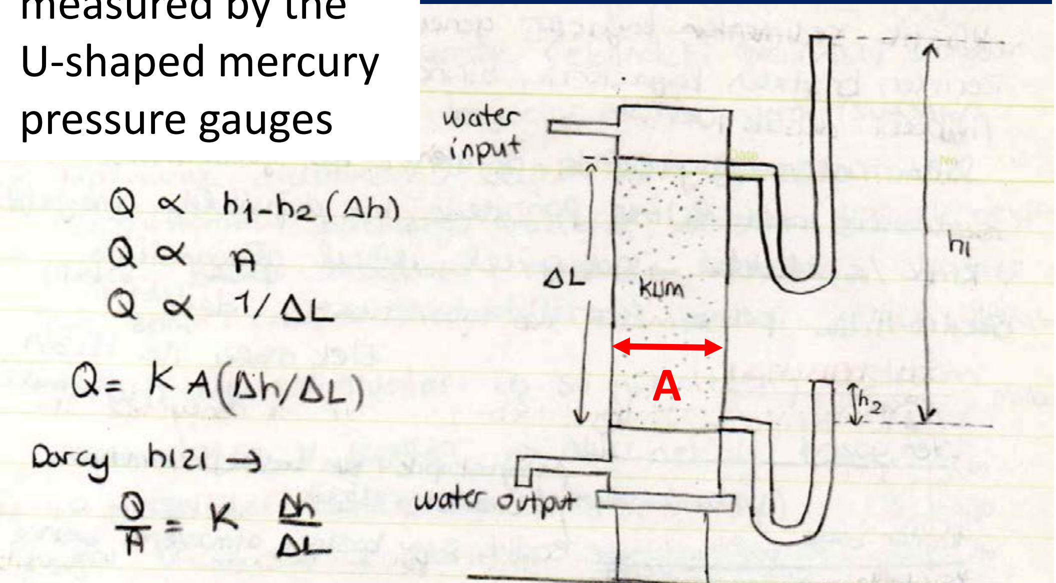
D. Perched Aquifer a special case of an unconfined aquifer which occurs wherever an impervious or semi-pervious layer of limited areal extent is located between the regional water table and the ground surface.

Italy, 2015


Henkel

DARCY’S LAW AND HYDRAULIC PROPERTIES OF AQUIFERS

Length: 3.5 m,
diameter: 35 cm
Pressure is measured by the U-shaped mercury pressure gauges



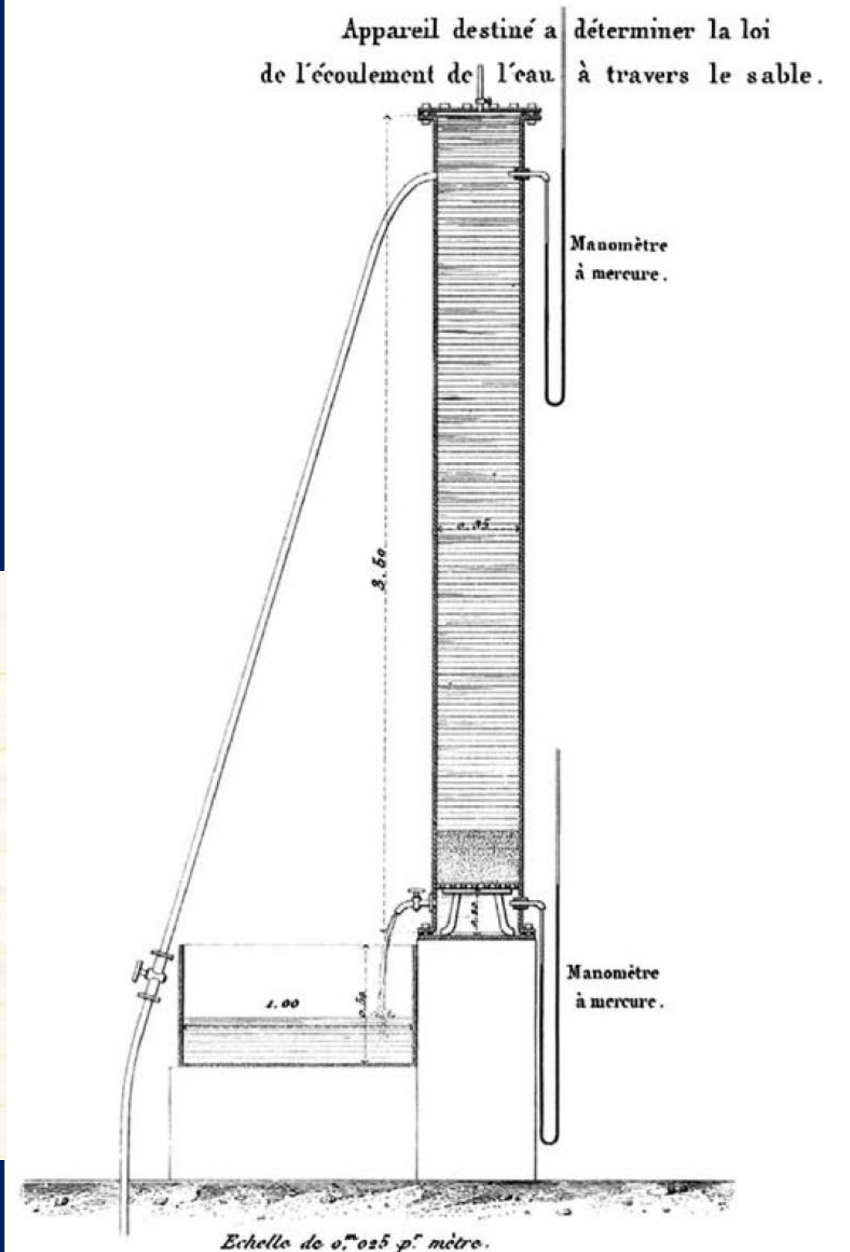


Fig. 5 Darcy's original sand column apparatus (Darcy 1856, Plate 24, Fig.3)

LES

FONTAINES PUBLIQUES

DE LA VILLE DE DIJON

EXPOSITION ET APPLICATION

DES PRINCIPES A SUIVRE ET DES FORMULES A EMPLOYER

DANS LES QUESTIONS

DE

DISTRIBUTION D'EAU

OUVRAGE TERMINÉ

PAR UN APPENDICE RELATIF AUX FOURNITURES D'EAU DE PLUSIEURS VILLES

AU FILTRAGE DES EAUX

ET

A LA FABRICATION DES TUYAUX DE FONTE, DE PLOMB, DE TOLE ET DE BITUME

PAR

HENRY DARCY

INSPECTEUR GÉNÉRAL DES PONTS ET CHAUSSÉES.

La bonne qualité des eaux étant une des choses qui contribuent le plus à la santé des citoyens d'une ville, il n'y a rien à quoi les magistrats aient plus d'intérêt qu'à entretenir la salubrité de celles qui servent à la boisson commune des hommes et des animaux, et à remédier aux accidents par lesquels ces eaux pourraient être altérées, soit dans le lit des fontaines, des rivières, des ruisseaux où elles coulent, soit dans les lieux où sont conservées celles qu'on en dérive, soit enfin dans les puits d'où naissent des sources.

(De Jussieu, *Hist. de l'Académie royale des sciences*, 1733, p. 351.)

PARIS

VICTOR DALMONT, ÉDITEUR,

Successeur de Carilian-Gœury et Vve Dalmont,

LIBRAIRE DES CORPS IMPÉRIAUX DES PONTS ET CHAUSSÉES ET DES MINES,

Quai des Augustins, 49.

1856

Fig. 2 Darcy's famous 1856 *Les Fontaines* report (from Hubbert 1969)

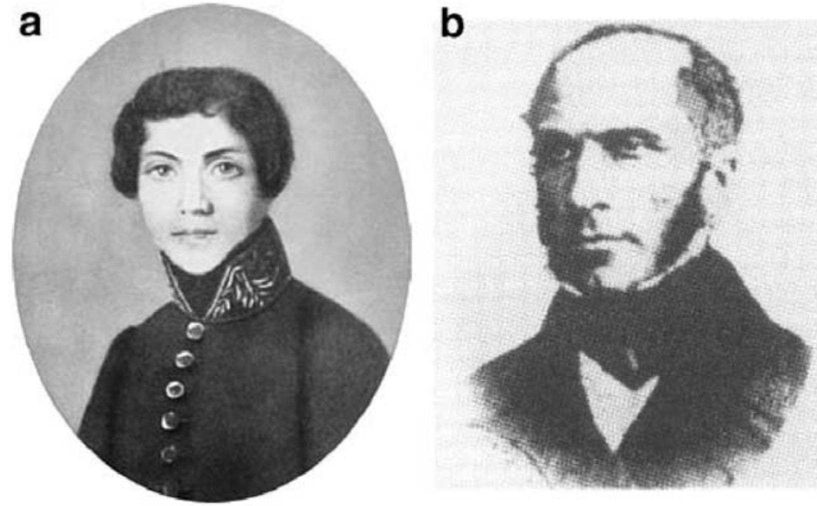
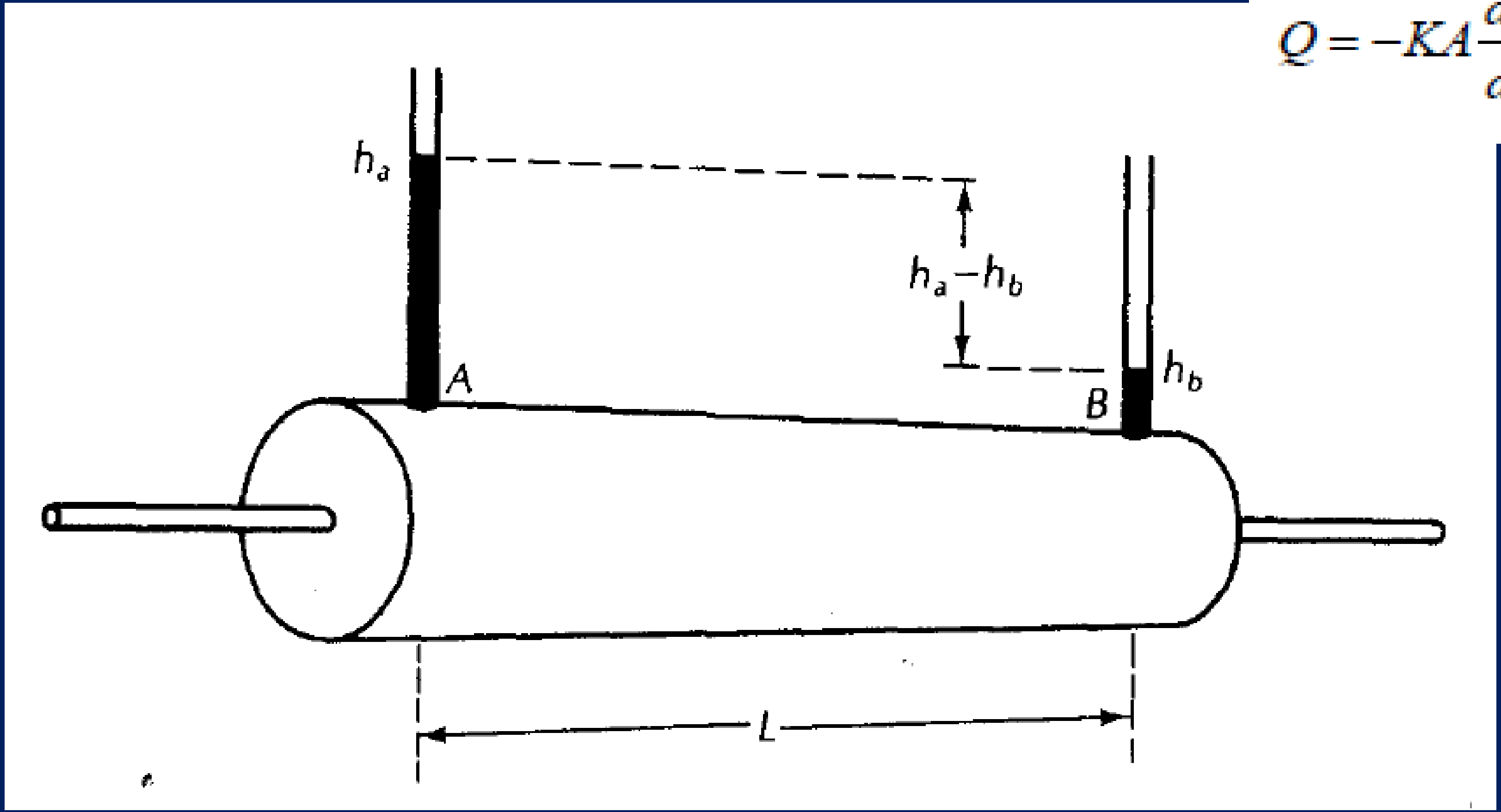


Fig. 1 **a** Henry Darcy in 1821. (P. Darcy 1957). **b** Henry Darcy in the later years of life. Portrait by F. Perrodin from the collection of the Bibliothéque Municipale de Dijon (from Philip 1995; Brown 2002a)

Darcy’s Law states that the flow rate or discharge through a porous medium is proportional to the head loss and iversely proportional to the length of the flow path.

$$Q = -KA\frac{dh}{d\ell}$$



Specific discharge (volume flow rate per unit cross sectional area normal to the direction of flow): $q = \frac{Q}{A}\ [\frac{L}{T}]$

Darcy has shown that specific discharge (q) is directly proportional with (–Δh) and inversely proportional with Δl and K (hydraulic conductivity)

Hydraulic conductivity , K, represents the rate of flow of water through a unit cross-sectional area perpendicular to the direction of flow under a unit hydraulic gradient. K is a function of both FLUID and MEDIUM properties.

$$K = \frac{\gamma}{\mu} * k$$

20.3 °C equal to 1
20 °C equal to 0.993
21 °C equal to 1.018

K= Hydraulic conductivity m/s
k= intrinsic permeability which is dependent solely on the medium properties m/s
ɣ= specific weight of water N/m^3
μ= dynamic viscosity $N.s/m^2$

$$\boldsymbol{k = cd^2}$$

C = shape factor accounting for the effects of stratification and packing
d = average pore size or mean grain diameter of the granular material within the aquifer

Transmissivity, t, is the rate of flow per unit width through the entire thickness of an aquifer per unit hydraulic gradient.

$T = Kb$

b aquifer thickness. This concept of T is valid only in 2-D flow.

HYDRAULIC HEAD AN FLUID POTENTIAL

Groundwater flows from states of higher energy levels to states of lower energy. The energy state at any point within an aquifer can be presented by the hydraulic head, h, which is a function of the pressure and potential energy per unit weight of the fluid.
The kinetic energy of the water in the aquifer is neglected because of the small magnitude of groundwater velocities.