



**GGY 4031**  
**LECTURE NOTES 3**

# Basic Properties of Fluids, Flows and Sediment

Three (3) main types of simple fluids:

- Water, air and ice

Properties of fluids

- ✓ Density-determines magnitude of forces or stresses acting within fluid
- ✓ Viscosity-describes the ability of fluid to flow

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Water: Transport of material in water is by far the most significant of all transport mechanisms. Water flows on the land surface in channels and as overland flow. These flows may be strong enough to carry coarse material along the base of the flow and finer material in suspension

Air: Wind blowing over the land can pick up dust and sand and carry it large distances. The capacity of the wind to transport material is limited by the low density of air.

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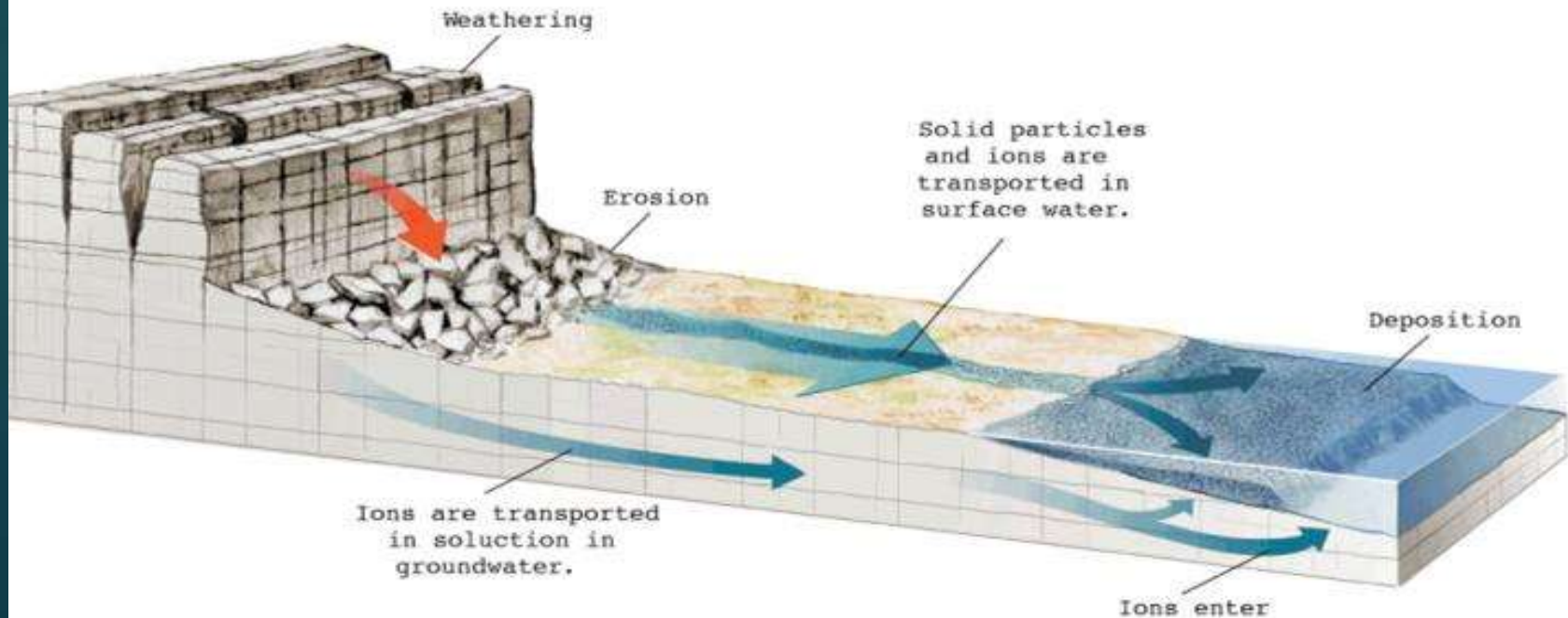
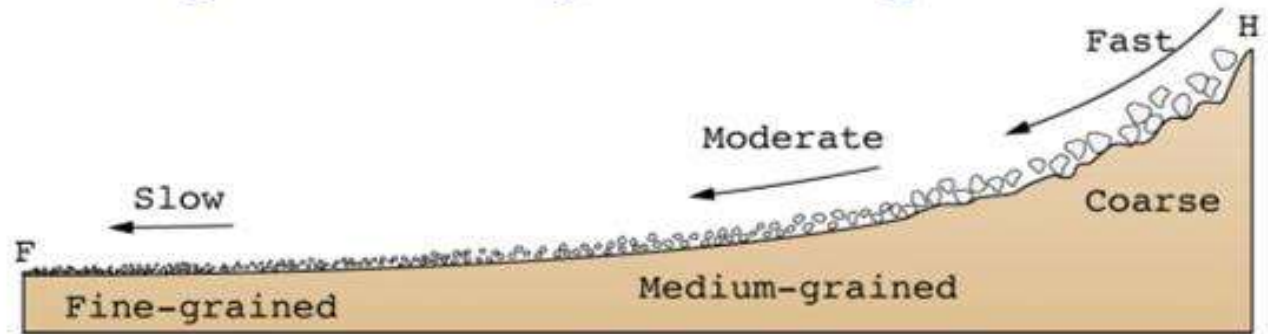
- *Ice*: Water and air are clearly fluid media but we can also consider ice as a fluid because over long time periods it moves across the land surface, **albeit** very slowly. Ice is therefore a rather high viscosity fluid that is capable of transporting large amounts of clastic debris

## *Dense sediment and water mixtures*

- High concentration of sediment in water mixture forms a **debris flow**, which can be thought of as a **slurry** with a consistency similar to that of wet concrete.

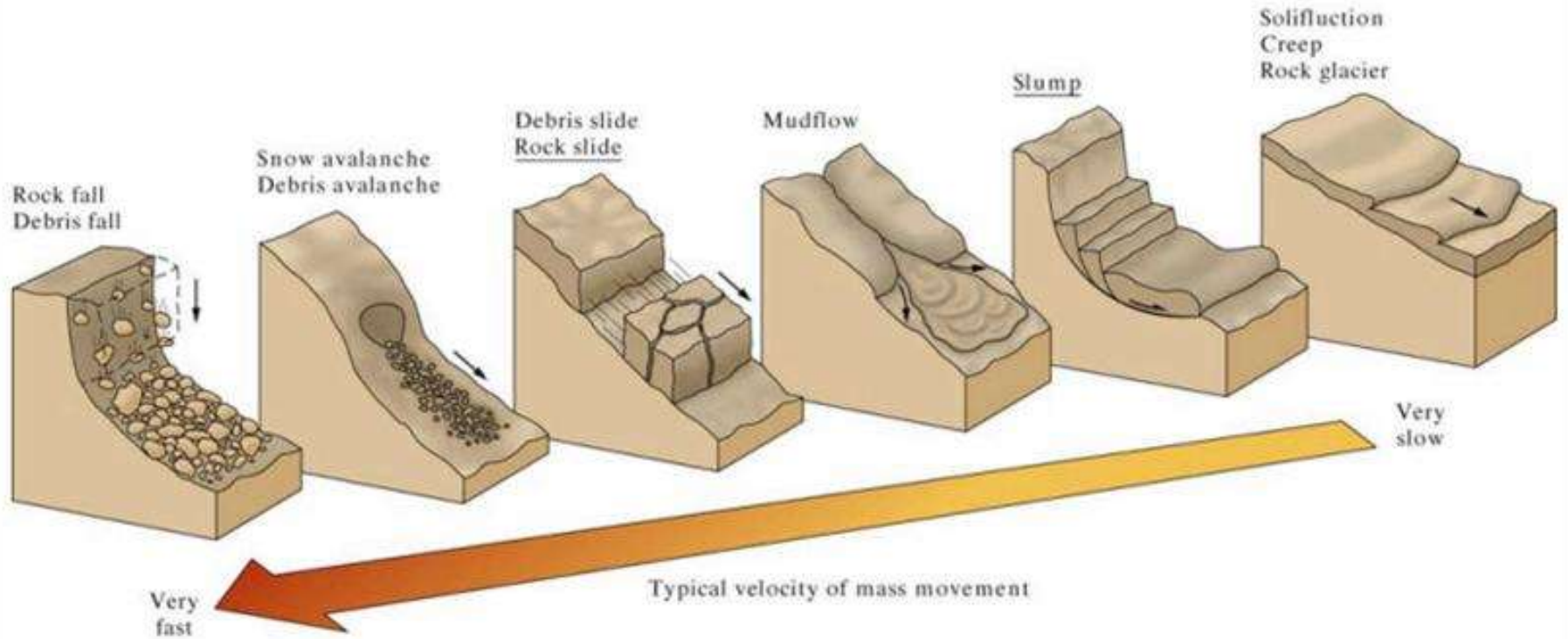
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*From weathering to deposition:  
sorting and modification of clastic particles*



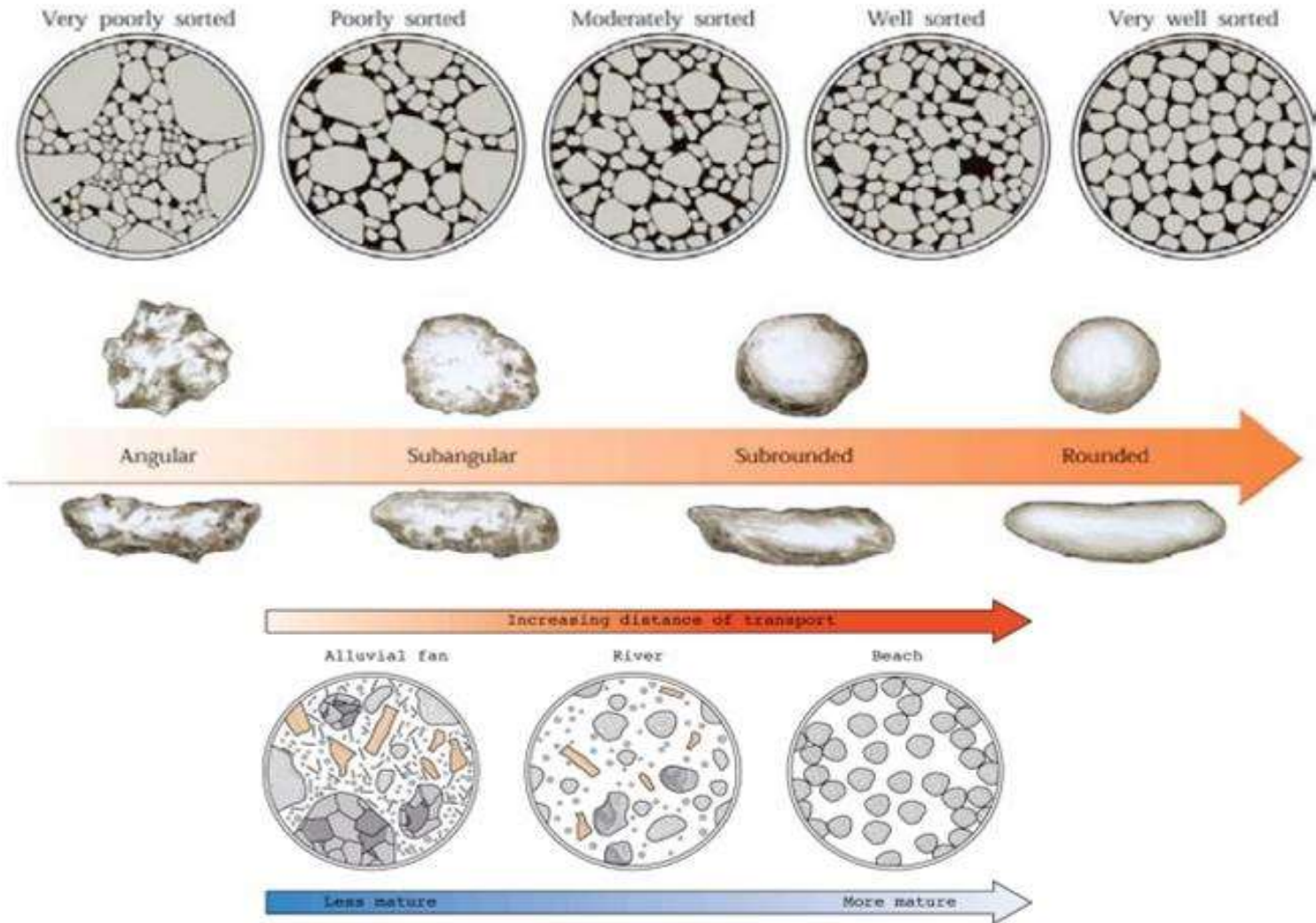
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*Different kinds of mass movements, variable velocity (and other factors)*



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## *Effects of transport on rounding, sorting*



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## Fundamental Physical Properties of Fluids

- **Density ( $\rho$ )**
- **Viscosity ( $\mu$ )**

Viscosity - resistance to flow, or deform under shear stress.

- Air - low
- Water - low
- Ice - high

Note: fluids with low viscosity flow readily and fluids with high viscosity flow sluggishly. For example, air has very low viscosity and ice has very high viscosity. Water has low viscosity; honey has high viscosity.

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## Types of Flow

- **Laminar flows**: all molecules within the high viscosity fluid move parallel to each other in the direction of transport. In heterogeneous fluids almost no mixing occurs during laminar flow. It can be visualized as a series of parallel sheets or filaments, referred to as **streamlines**
- **Turbulent flows**: molecules in the low viscosity fluid move in all directions but with a net movement in the transport direction. In heterogeneous fluids, there is a thorough mixing in turbulent flows.

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Turbulence is thus an irregular or random component of fluid motion. Highly turbulent water masses are referred to as **eddies**.

Flows can be assigned a parameter called a Reynolds number (Re), that can be used to distinction between laminar and turbulent motion.

The Reynolds number is obtained by relating the following factors:

- ✓ the velocity of flow ( $v$ ), the ratio between the density of the fluid and viscosity of the fluid ( $\nu$  – the fluid kinematic viscosity) and a ‘characteristic length’ ( $l$  – the diameter of a pipe or depth of flow in an open channel).

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$$Re = \frac{\rho v l}{\mu}$$

where  $\rho$  = density;  $v$  = velocity;  $l$  = characteristic linear dimension;  $\mu$  = dynamic viscosity.

This formula is a dimensionless quantity that indicates the extent to which a flow is laminar or turbulent

- ✓ Reynolds value is low ( $<500$ ), the flow is laminar
- ✓ Reynolds value is high ( $>2000$ ), the flow is turbulent

**Note:** Fluids with low kinematic viscosity, such as air, are turbulent at low velocities

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## Laminar vs. Turbulent Flow

These two modes of flow are dependent upon:

1. Velocity
2. Fluid viscosity
3. Bed roughness

• Laminar Flow: streamlined, uniform current. Requires:

- Low fluid velocity
- High viscosity
- Smooth beds

• Turbulent Flow: discontinuous, distorted, flow with considerable motion perpendicular to primary flow direction.

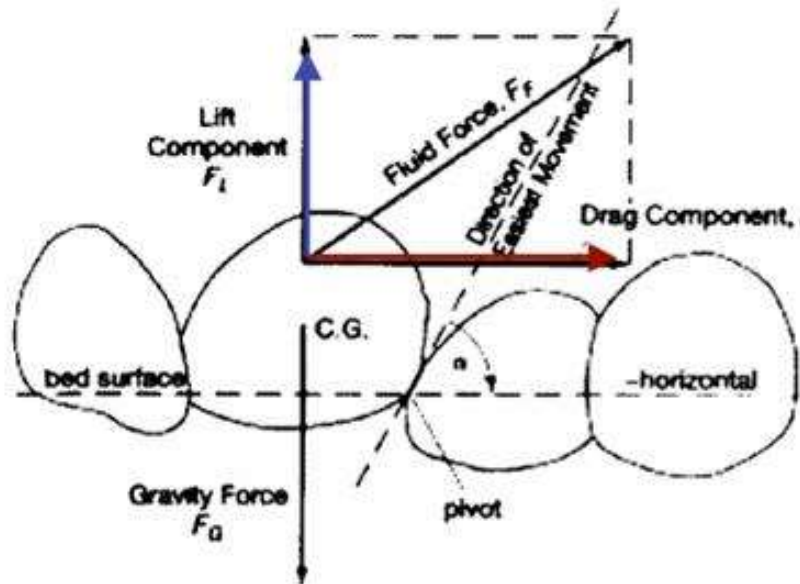
– Eddies - highly turbulent flow (water and air)

• Eddy Viscosity - internal friction at a larger scale

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## Particle Entrainment:

Forces acting on a grain

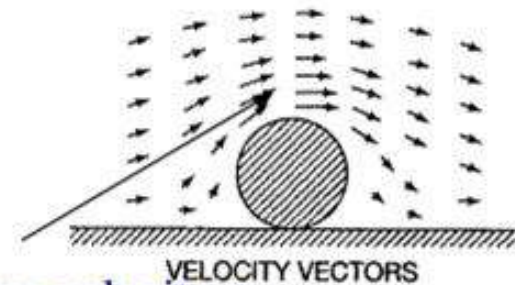
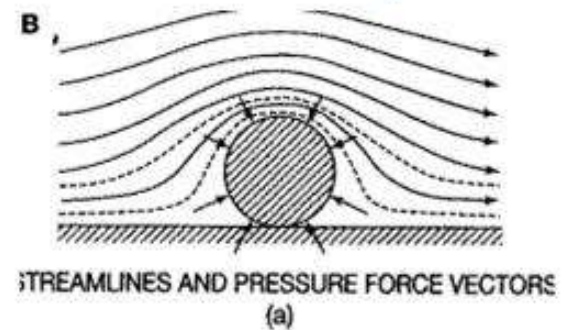


Drag ( $F_D$ )      Lift ( $F_L$ )

$F_D \sim \tau$  (shear stress) / # of grains

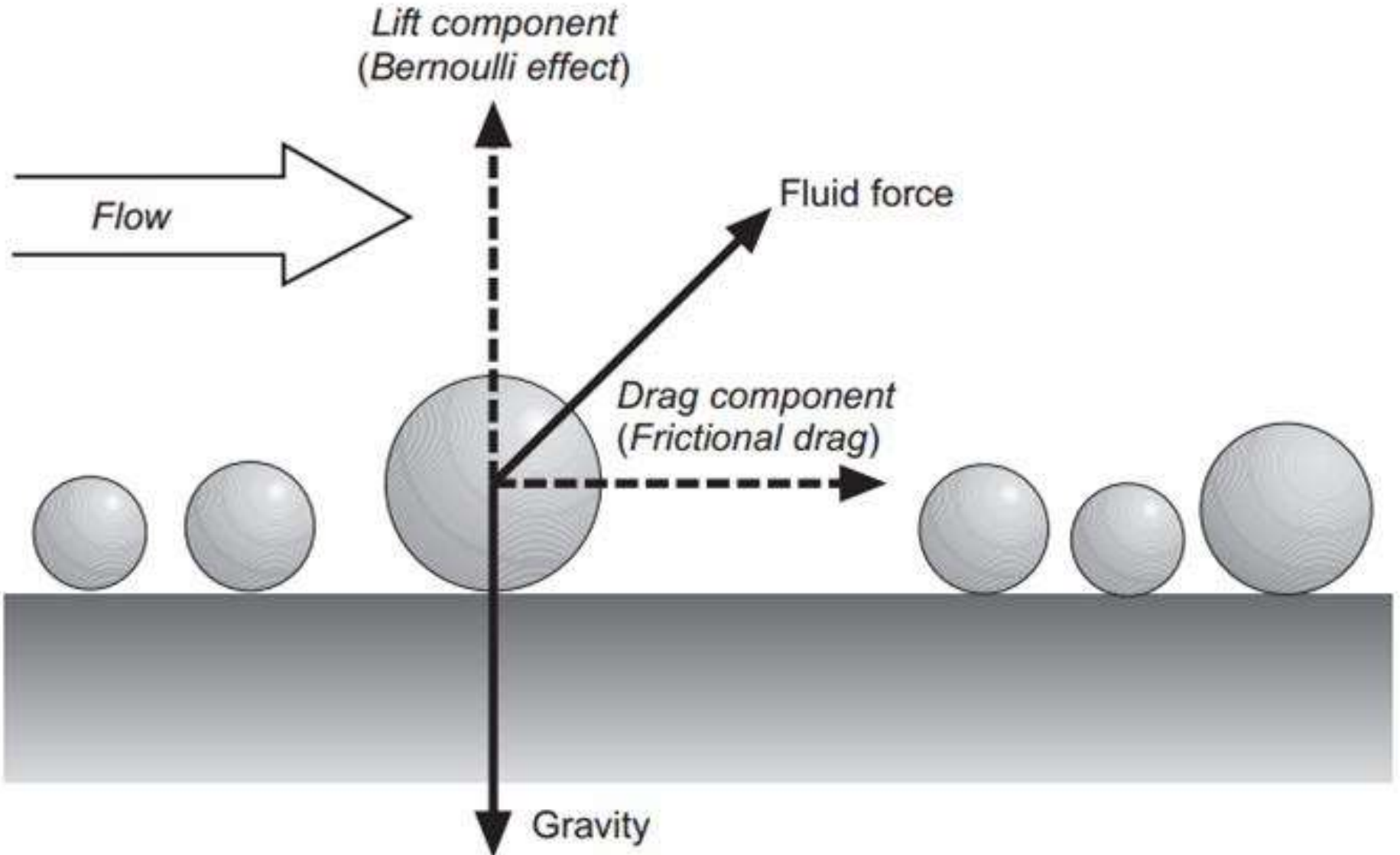
$F_L$  - *Bernoulli Effect* - Pressure diff. top & bottom of a grain

**Lift component:**  
flow lines compress

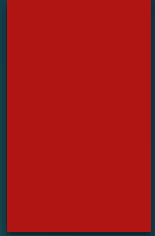


Increase velocity =  $\Rightarrow$   
lower pressure

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## Modes of Sediment Transport

- Suspension transport (floatation)
- Bedload transport (traction + saltation)

## Suspension transport (floatation)

- ✓ Sediment transport results from a balance between downgravitational forces on the grains and upward forces derived from the fluid turbulence
- ✓ Sediment does not come into contact with the streambed suggesting that turbulent flow has a net upward energy flux

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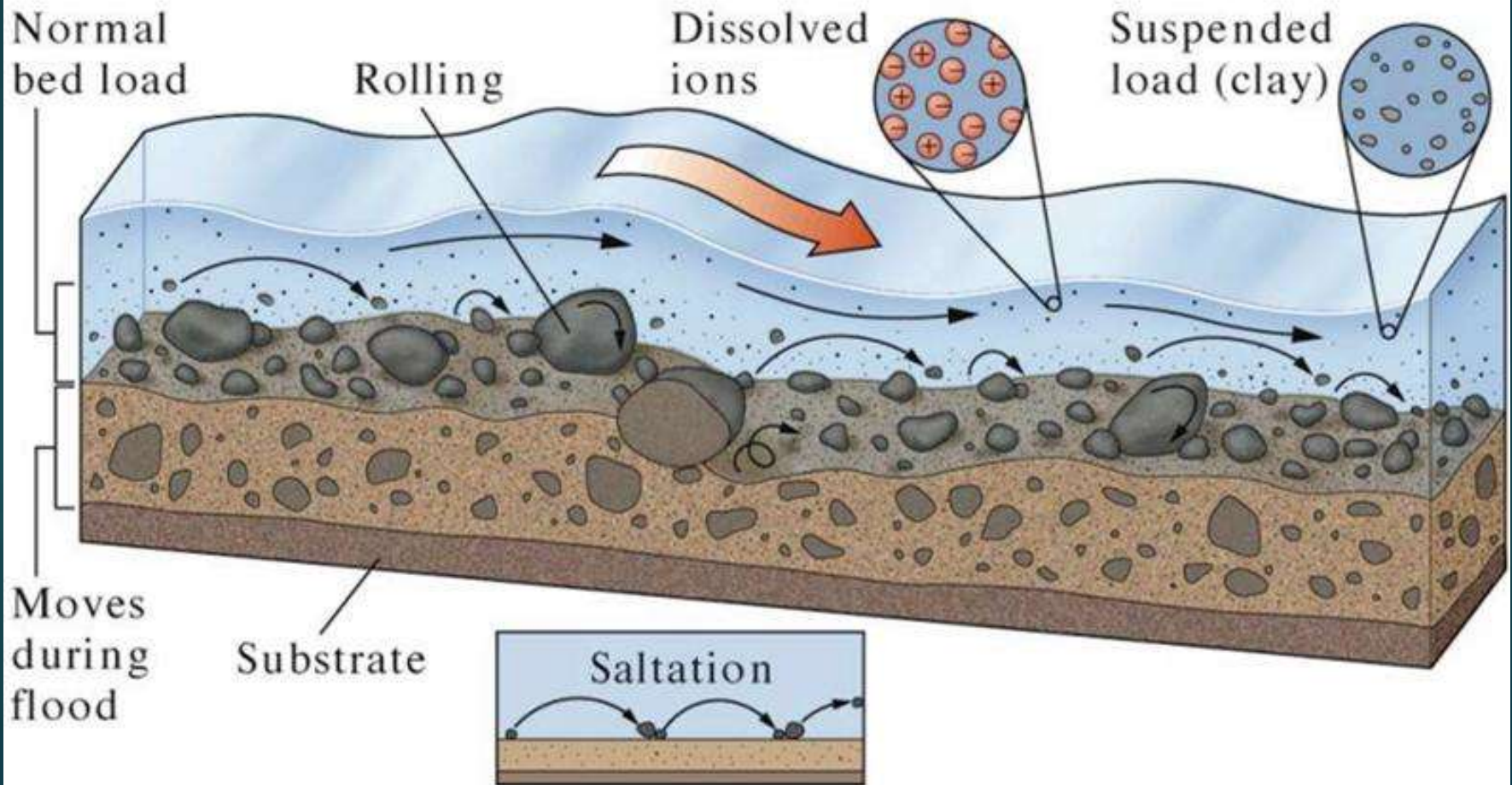


## Bedload transport

- ✓ Saltation: jumping motion of grains close to the streambed during vigorous bedload transport
- ✓ Traction (Rolling or sliding): usually occurs when large clasts set in motion either due to the effects of saltation or increased current velocities
- ✓ Creep: involves the push of grains along a bed by saltating grains

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## *Modes of sediment transport in water*



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## FLOW REGIMES

- $Fr < 1$  (subcritical): lower flow regime in which ripples, dunes and lower plane beds are stable
- $Fr > 1$  (supercritical): upper flow regime where plane beds and antidunes form