CHAPTER III : MECHANISM OF CONTINUOUS DEFORMATION

III-1 FLOW UNIT AND MECHANISM OF DEFORMATION

Plastic deformation results from the relative movement of structural elements:

III-1-1 FRAGMENT OF ROCKS AND CRYSTALS

Fracture, frictional grain-boundary sliding ->> Cataclastic flow:
Favoured by low $\sigma_c$

III-1-2 INTRA-CRYSTAL DOMAINS

Crystal-plastic flow: Favoured by high $\sigma_c$

Intracrystalline slip: Edge dislocation

Burgers vector

Dislocation line

A dislocation has the ability to climb via the exchange atoms-vacancies by solid state diffusion in the crystal lattice.

Intracrystalline slip: Screw dislocation

Dislocation loop,
Characterized by a sliding plane, and a slip direction.

Dislocation glide + dislocation climb = dislocation flow
Dislocation distorts the crystal lattice and introduce elastic energy (red spots on the sketch on the left) that can be sufficient to drive their motion.

Dislocations may aggregate within stable, low-energy arrays such as dislocation wall. Dislocation walls lead to subgrain boundaries (1 to 5° lattice misorientation) and grain boundaries when the misorientation is higher than 10°.

Mechanical twinning \(\iff\) deformation twinning \(\iff\) glide twinning

Material move away from areas of high normal stress towards regions of low normal stress through either solid-state diffusion (atoms-vacancies exchange through the lattice: Nabarro-Herring creep or along the grain boundaries: Cobble creep) or transport in solution (Solution creep).

In general, no single process operates alone.
CHAPTER III: MECHANISM OF CONTINUOUS DEFORMATION

III-2 DEFORMATION MECHANISMS

III-2-1 AT LOW TEMPERATURE \(< 0.3 \, \text{Tf}\)

The higher the density of dislocation, the more difficult it becomes for any dislocation to move: HARDENING

III-2-2 AT MEDIUM TEMPERATURE \((0.4 \text{ to } 0.6 \, \text{Tf})\)

Diffusion become more active—>>RECOVERY PROCESSES and DYNAMIC RECRYSTALLIZATION

Climbing rate < gliding rate => Climb is the controlling factor
CHAPTER III: MECHANISM OF CONTINUOUS DEFORMATION

III-2 DEFORMATION MECHANISMS

III-2-2 AT MEDIUM TEMPERATURE (0.4 to 0.6 Tf)

Dynamic equilibrium between hardening and recovering processes

Dynamic recrystallization

Dislocation climbs

Diffusive mass-transfer:

Nabarro-Herring creep: Diffusion through the lattice
Coble creep: Diffusion along grain boundaries
Solution creep: Dissolution-precipitation
Superplastic creep: Coherent grain boundary sliding without opening pores between adjacent crystal
III-2 DEFORMATION MECHANISMS
III-2-4 ABOVE SOLIDUS \( (T > T_f) \)
CHAPTER III: MECHANISM OF CONTINUOUS DEFORMATION

III-2 DEFORMATION MECHANISMS
III-2-4 ABOVE SOLIDUS (T > T_f)
III-3 THE EFFECT OF FLUIDS

Molecules move away from areas of high normal stress towards regions of low normal stress. They move along the grain boundaries by transport in solution. This mechanism of deformation is called solution creep.

Dissolution
Transport
Crystallization
Passive rotation of insoluble elements
III-4 CRYSTALLOGRAPHIC FABRICS

Ductile deformation by dislocation creep produces characteristic preferred orientations of mineral crystallographic axes. The pattern of CPO (Crystallographic Preferred Orientation) depends on:

- the slip systems that are actived (depends on temperature and stress)
- the geometry and the magnitude of the deformation

Coaxial deformation -> fabrics symetric to the principal axes of finite strain
Noncoaxial deformation -> asymmetric fabric

Preferred crystallographic orientation by dislocation glide

![Diagram showing preferred orientations](image-url)