

Morphology

Morphology– set of faces and edges which enclose a crystal

morphology $\dashrightarrow$ crystal structure

(external surfaces)

(internal structure)

ex) PbS (galena)

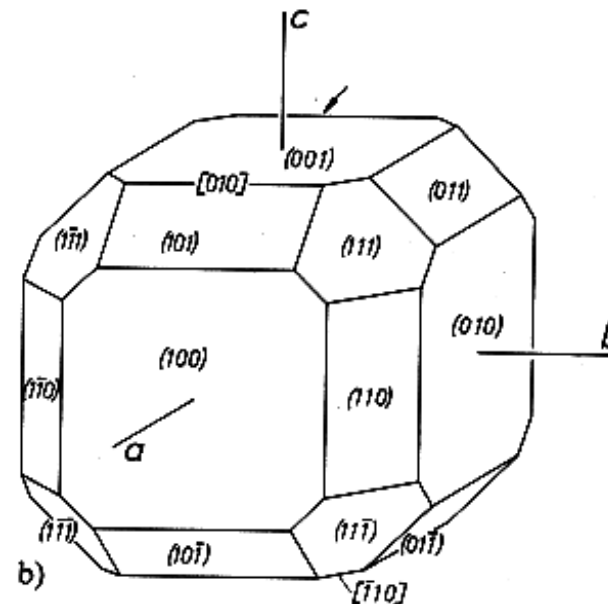
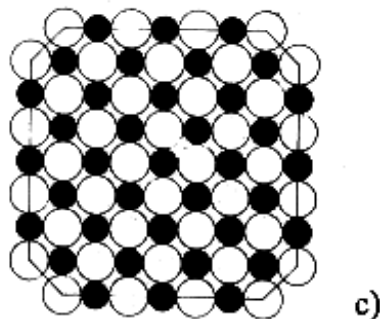
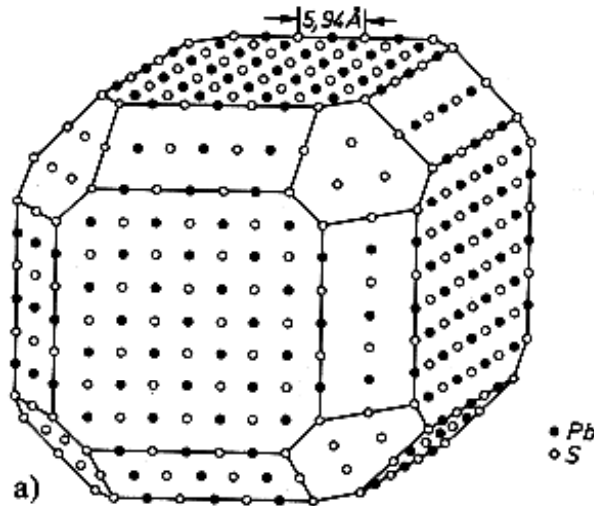
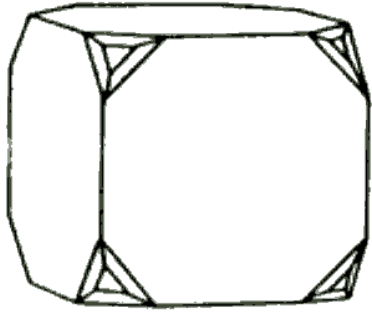


Fig. 4.1 a, b. Correspondence between crystal structure (a) and morphology (b) in galena (PbS). In a, the atoms are reduced to their centres of gravity (c) shows the atoms occupying the (100), (010) or (001) face.

PbS (galena), cubic

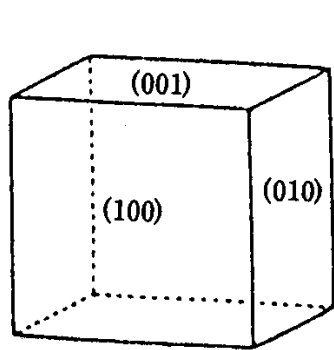


Morphology

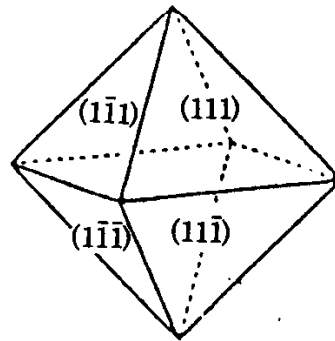
- Every crystal face lies parallel to a set of lattice planes:
parallel crystal faces correspond to the same set of planes.
- Every crystal edge is parallel to a set of lattice lines.
- Miller index- crystal faces
[uvw]- crystal edge
- Morphology- no information about the size of the unit cell
in principle ratio between one unit cell edge and another
- Lattice parameters known- angle between any pair of lattice
plane can be calculated and compared with the observed angles
between two crystal faces

Morphology

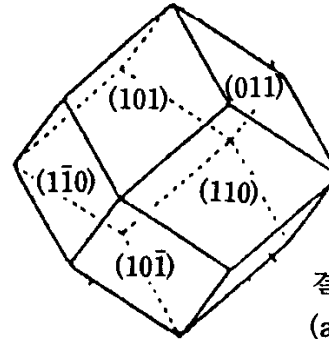
Form (결정형): 한 결정에서 외형을 이루는 동가면(equivalent faces)들의 집단, $\{hkl\}$ 로서 나타냄



(a)



(b)



(c)

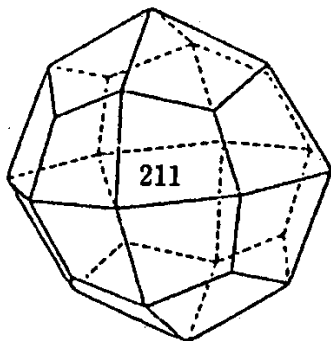
결정형과 취형

(a) $\{100\}$, 정육면체 (b) $\{111\}$, 정팔면체

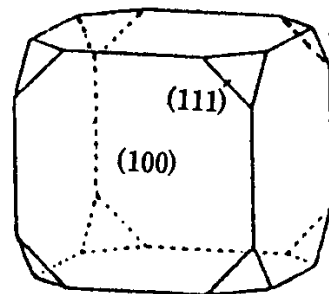
(c) $\{101\}$, 능면 십이면체 (d) $\{211\}$, 이십사면체

(e) $\{100\} \cdot \{111\}$, 정육면체와 정팔면체의 취형

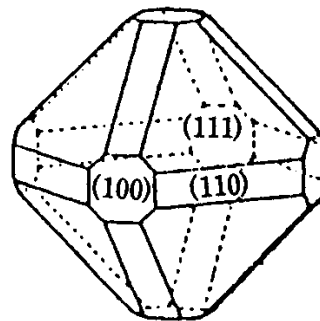
(f) $\{100\} \cdot \{111\} \cdot \{110\}$, 정육면체, 정팔면체, 정십이면체의 취형



(d)



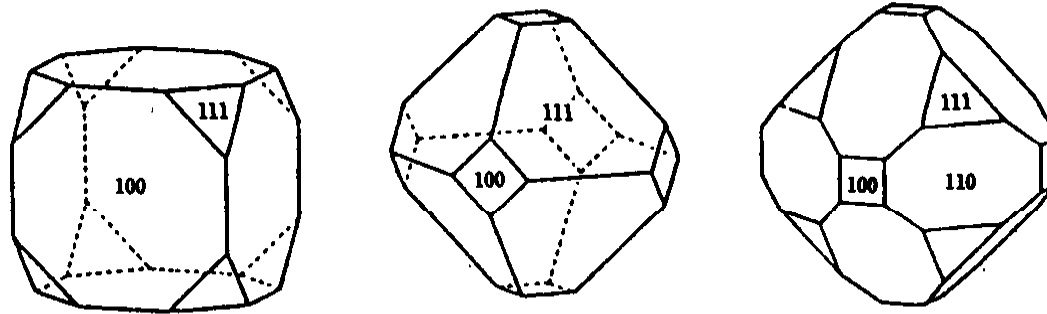
(e)



(f)

Morphology

Habit (정벽): 결정 성장 속도의 차이에 다른 결정 외면의 상대적인 발달에 따라 어떤 특정한 결정형이 두드러지게 잘 나타나는 성질



(a) 정육면체 정벽 (b) 정팔면체 정벽 (c) 능면 십이면체 정벽

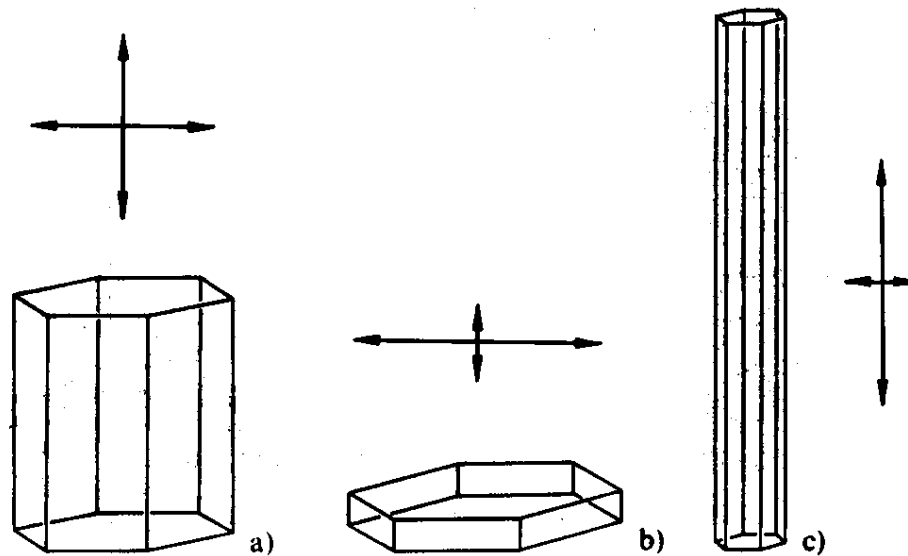


Fig. 4.2a-c. The three basic habits: a equant, b planar or tabular, c prismatic or acicular with the relative rates of growth in different directions shown by *arrows*

Morphology

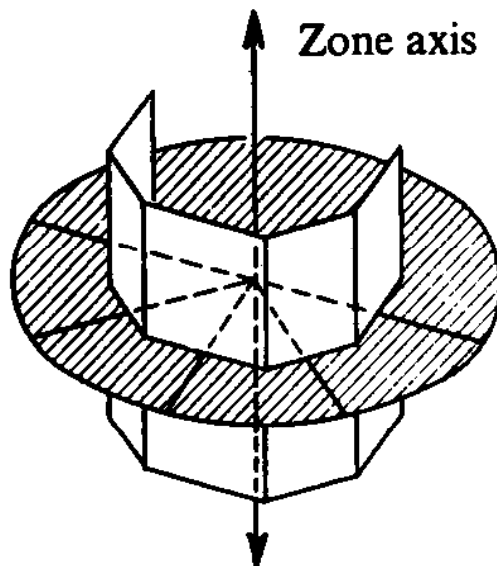
Zone: a set of crystal faces whose lines of intersections are parallel

Tautozonal: faces belonging to the same zone

Zone axis: a direction parallel to the lines of intersection

* normals to all the faces in a zone are coplanar

zone axis is normal to this plane



ex) galena crystal (PbS)

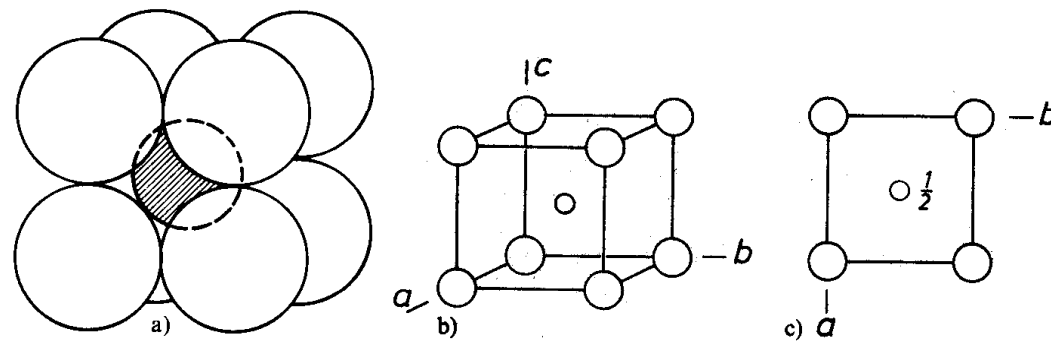
$$[(101)/(10\bar{1})] = [010]$$

*If (h_1, k_1, l_1) , (h_2, k_2, l_2) , (h_3, k_3, l_3) are tautozonal
if and only if

$$\begin{vmatrix} h_1 & k_1 & l_1 \\ h_2 & k_2 & l_2 \\ h_3 & k_3 & l_3 \end{vmatrix} = 0$$

Projections

- three dimensional objects $\rightarrow$ flat surfaces
- parallel projection



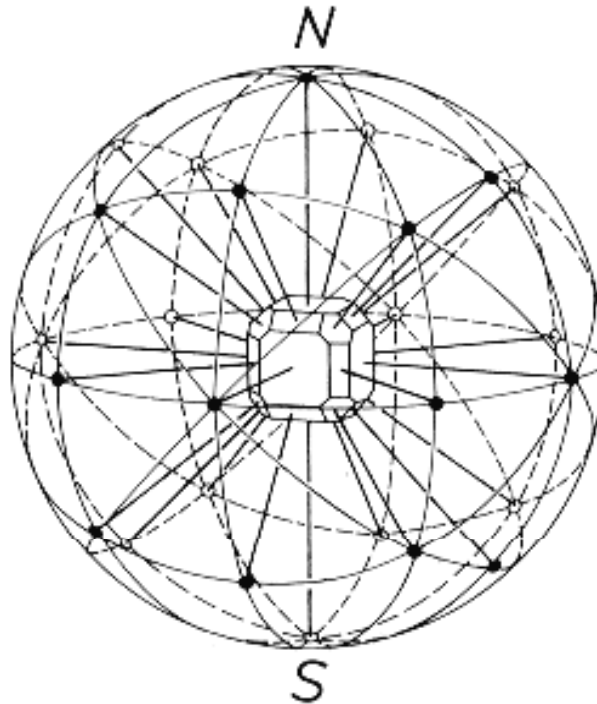
- stereographic- angular relationship between lattice planes
and directions

gnomonic

orthographic

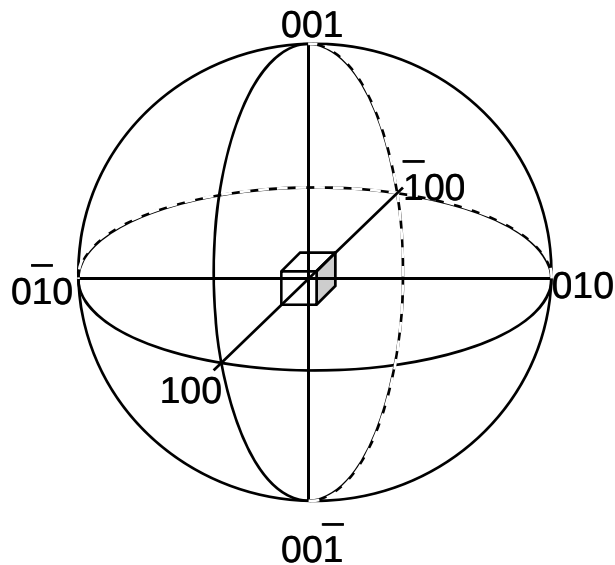
Stereographic Projections

- place a crystal at the center of the sphere
- draw normal to each faces from the center of the sphere
- cut the surface of the sphere in the indicated points (**pole**)
- **great circles**- circles whose radius is that of the sphere
- those faces whose pole lie on a single great circle- a single zone
- zone axis- perpendicular to the plane of the great circle



Stereographic Projection

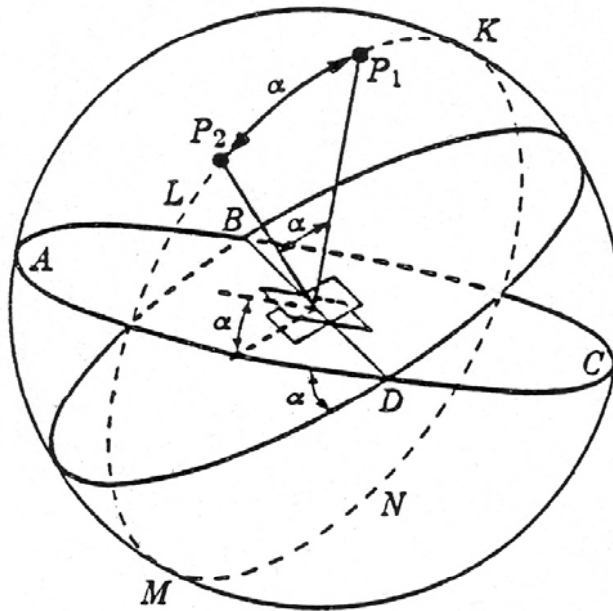
- Planes be represented by a set of plane normals radiating from some one point within the crystal
 - → Poles (representing plane)



{100} poles of a cubic crystal

Stereographic Projection

- B. Planes be represented by the trace which the extended plane makes in the surface of the sphere



When the plane passes through the center of the sphere

→ will intersect the sphere in a great circle (대원)

When the plane not passing through the center of the sphere

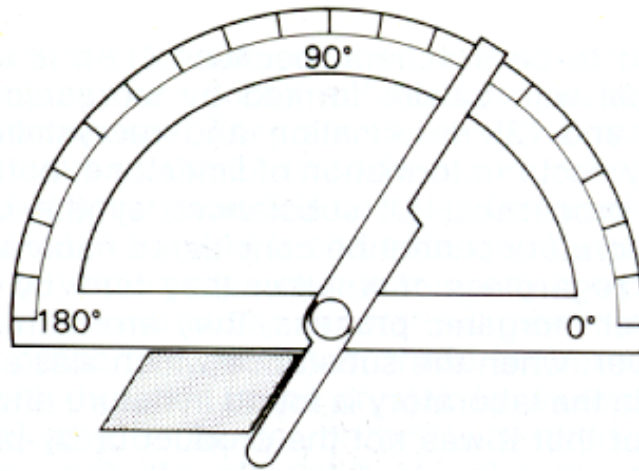
→ will intersect the sphere in a small circle (소원)

The angle between two planes :

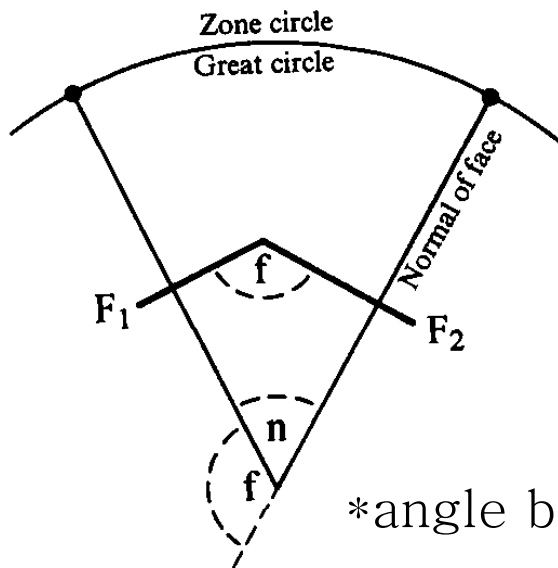
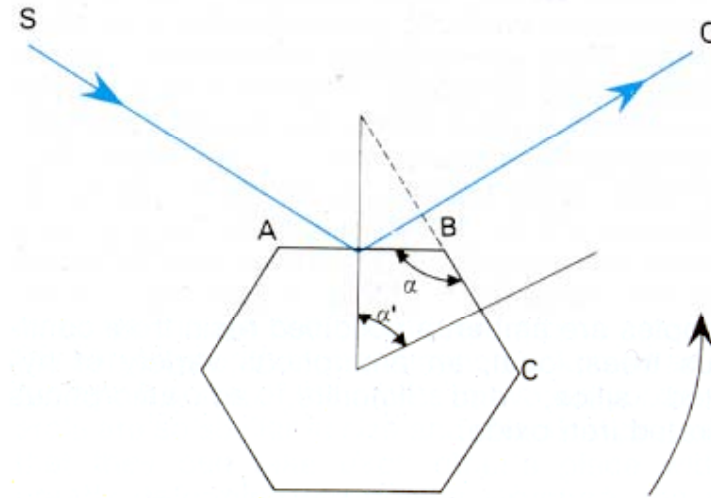
- 1) the angle between their great circles
- 2) the angle between their normals

Stereographic Projections

Contact goniometer

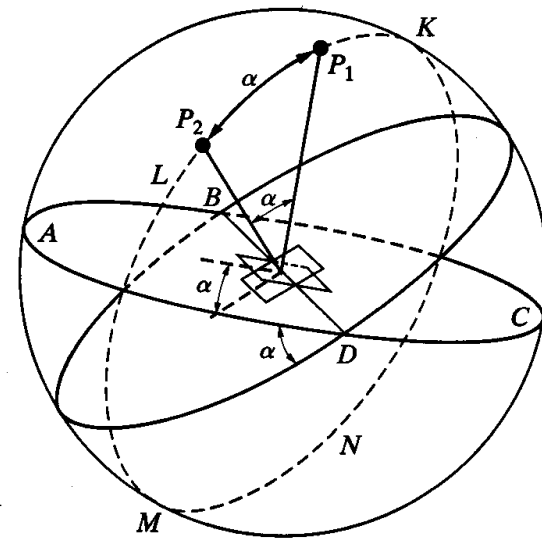


Reflecting goniometer



*angle between normals n

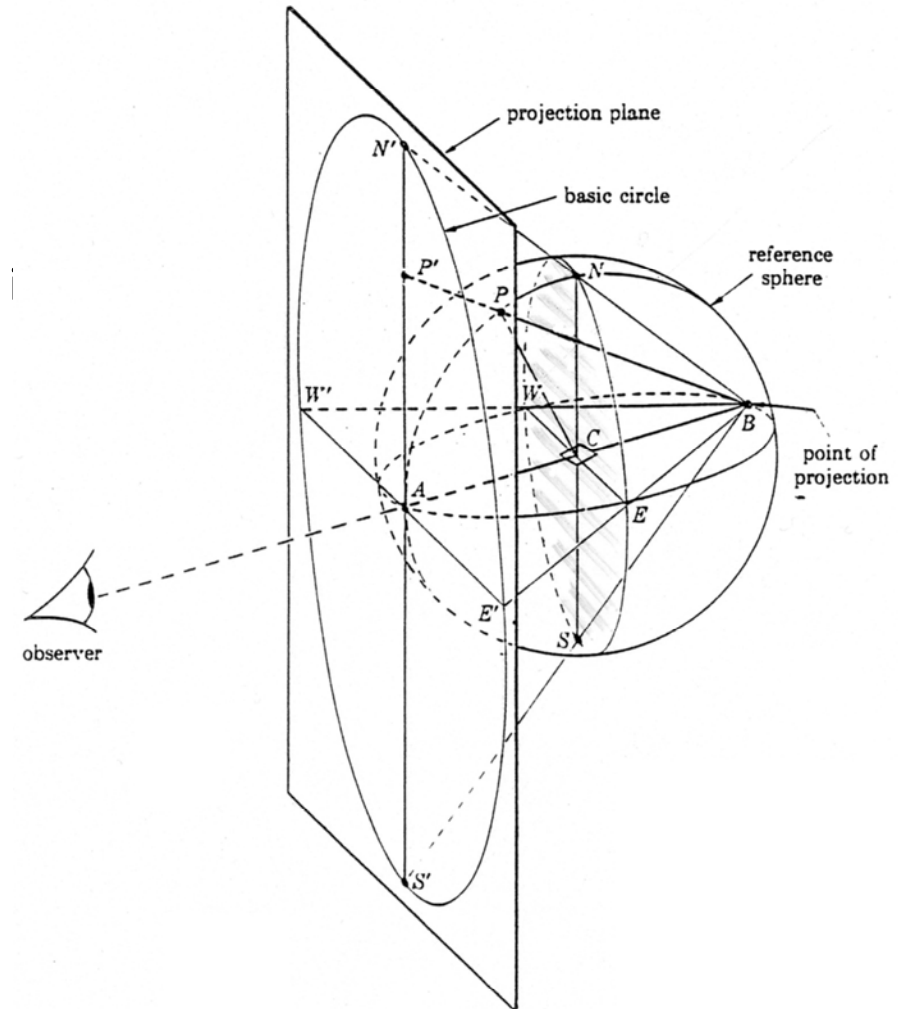
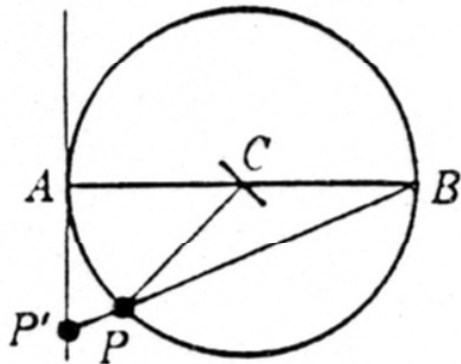
$$n = 180 - \text{dihedral angle } f$$



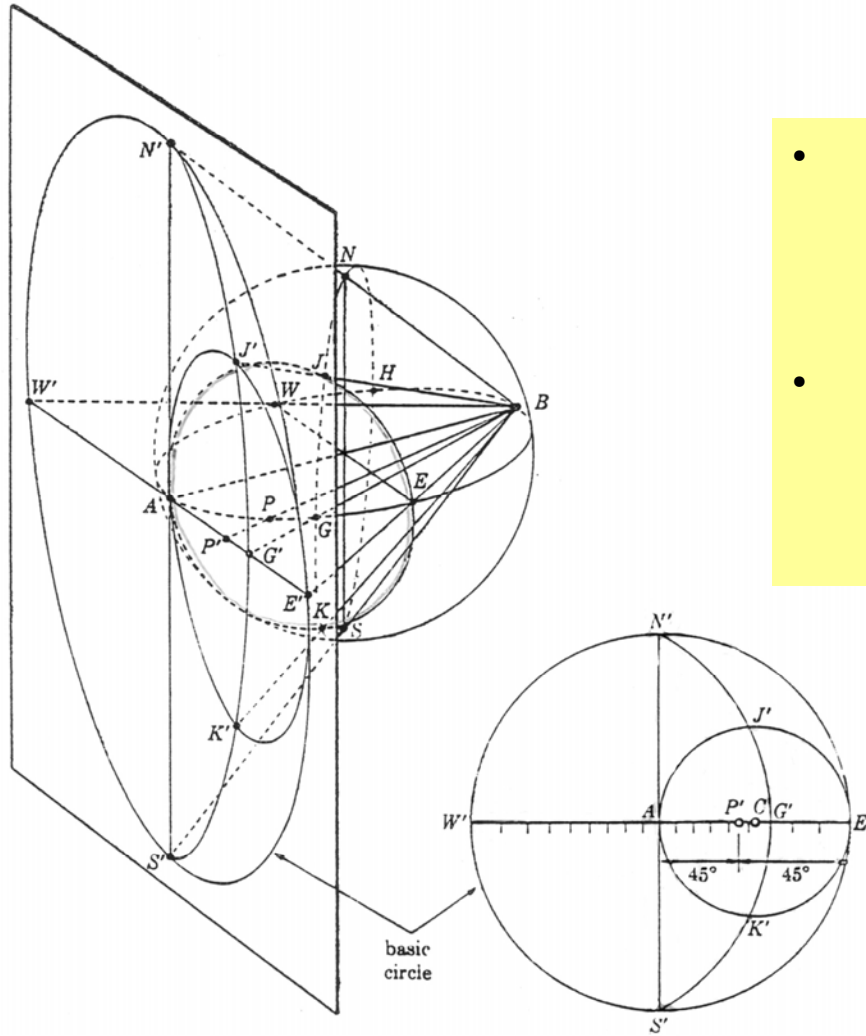
Stereographic Projections

- A lattice plane in a crystal
 - a. The plane C is represented by its normal CP.
 - b. The normal CP is represented by pole P.
 - c. The pole P is represented by its projection P'.

SECTION THROUGH
AB AND PC



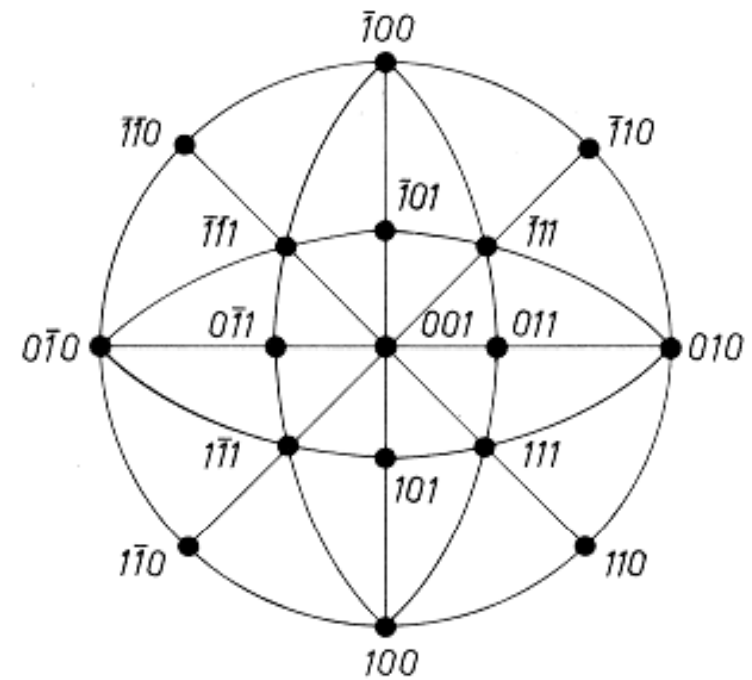
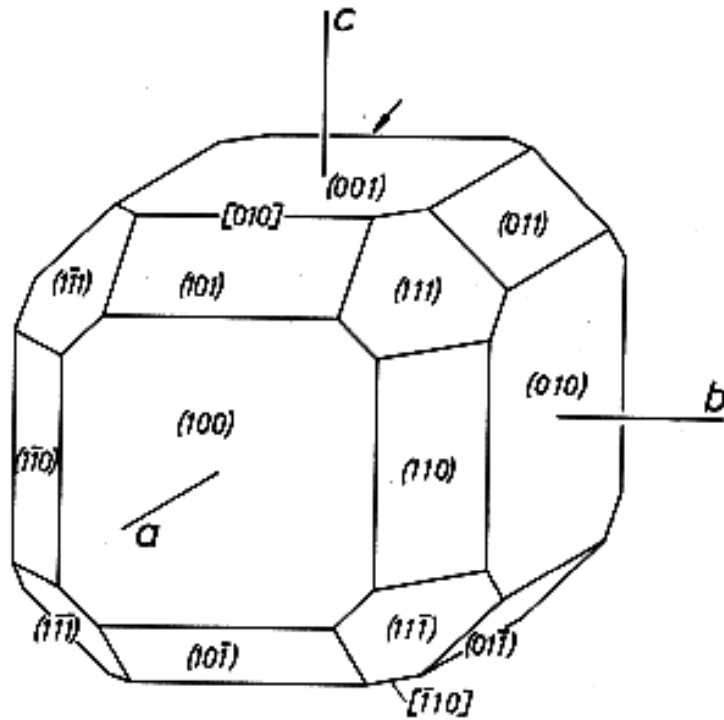
Great circle and small circle



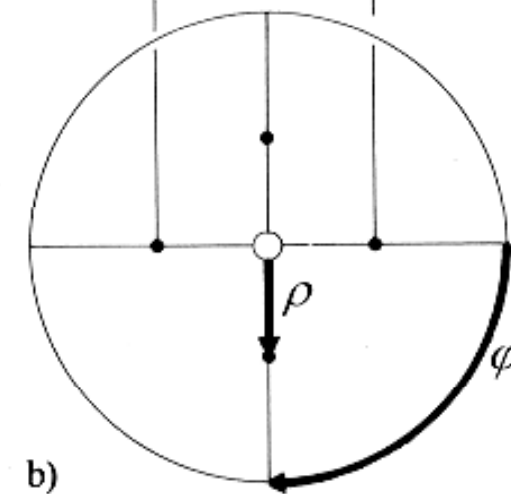
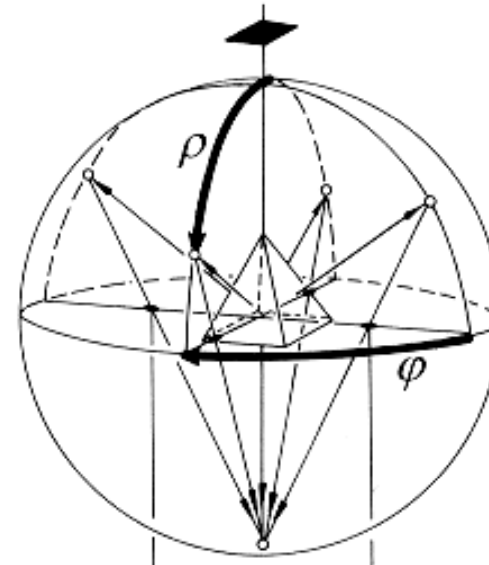
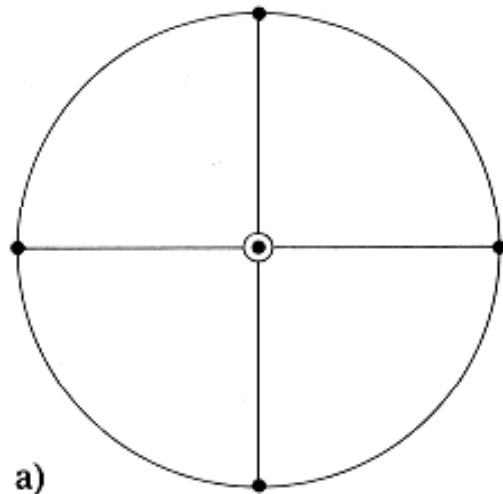
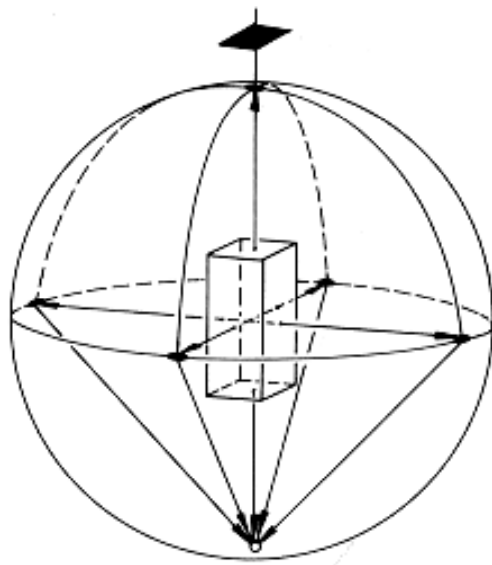
- Great circle
project as circular arcs, or as straight lines through the center of the projection
- Small circle
project as circles, but their projected center does not coincide with their center on the projection

Stereographic projection of great and small circles

Stereographic Projections

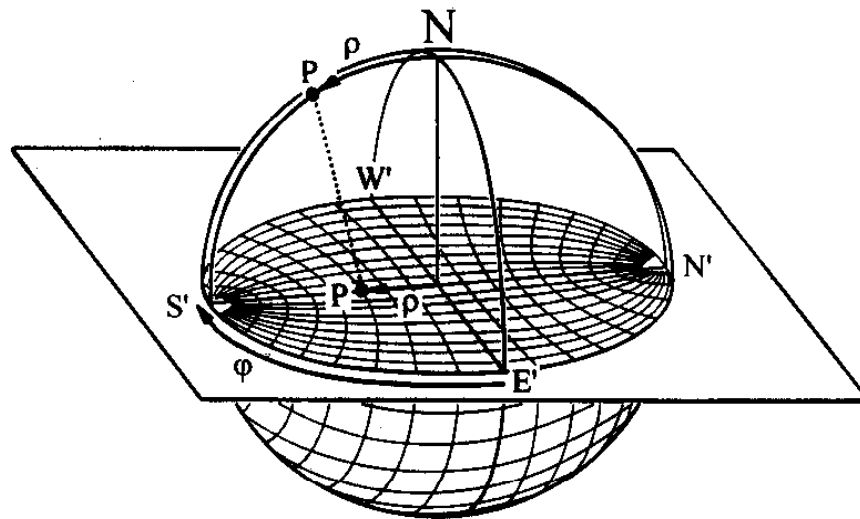


Stereographic Projections

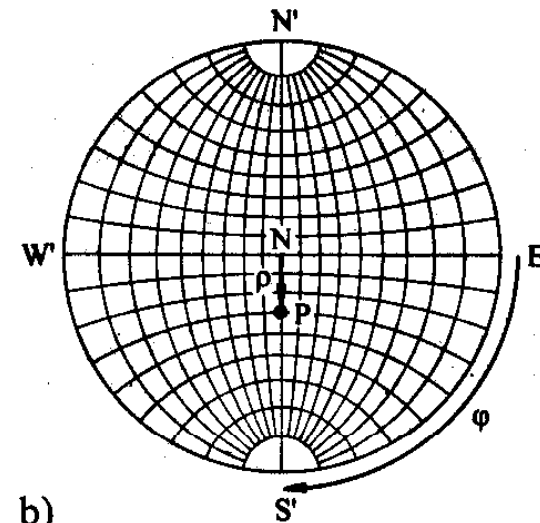


Stereographic Projections

- Wulff net: – a device to enable the measured crystal angles to be plotted readily as a stereographic projection.
- stereographic projection of the grid of a conventional globe oriented so that the $N'-S'$ direction lies in the plane of projection ($NS \perp N'S'$)
 - equator, all meridians – great circle
 - parallels except equator – small circle
 - azimuthal angle ϕ and pole distance ρ

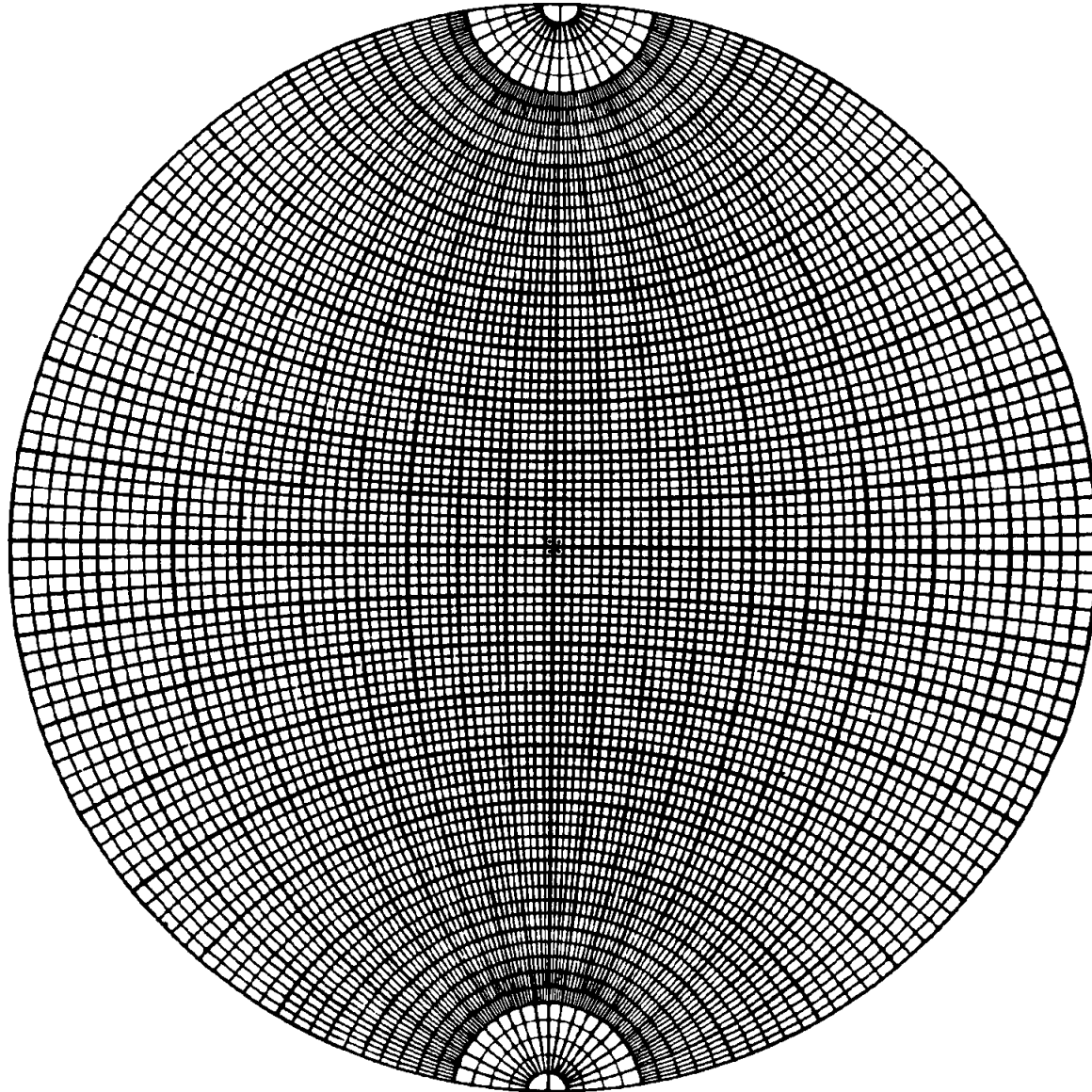


a)



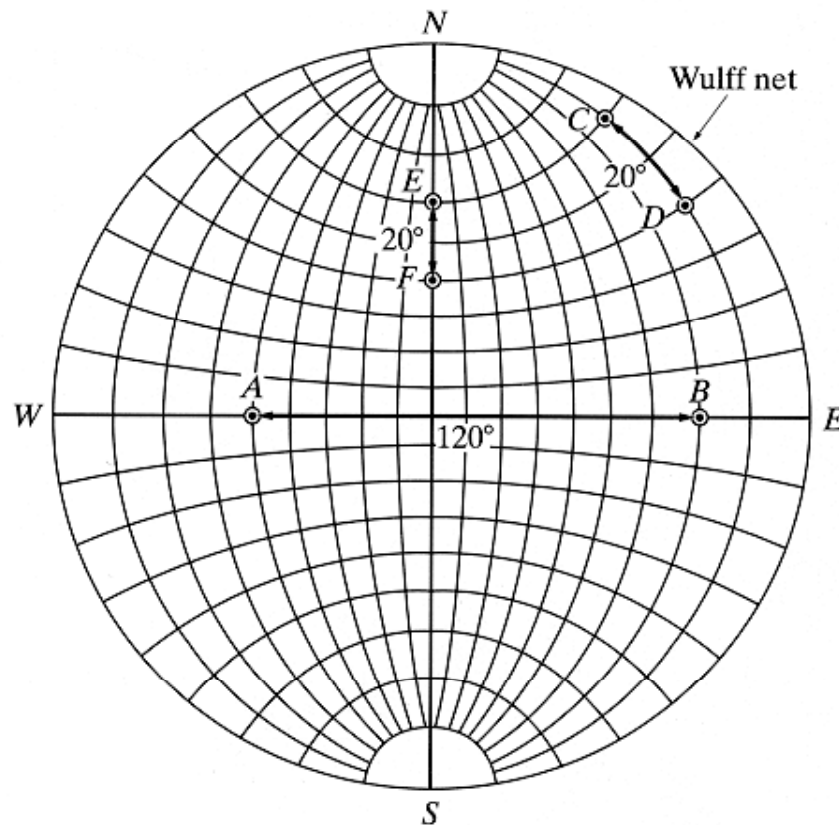
b)

Stereographic Projections



Stereographic Projections

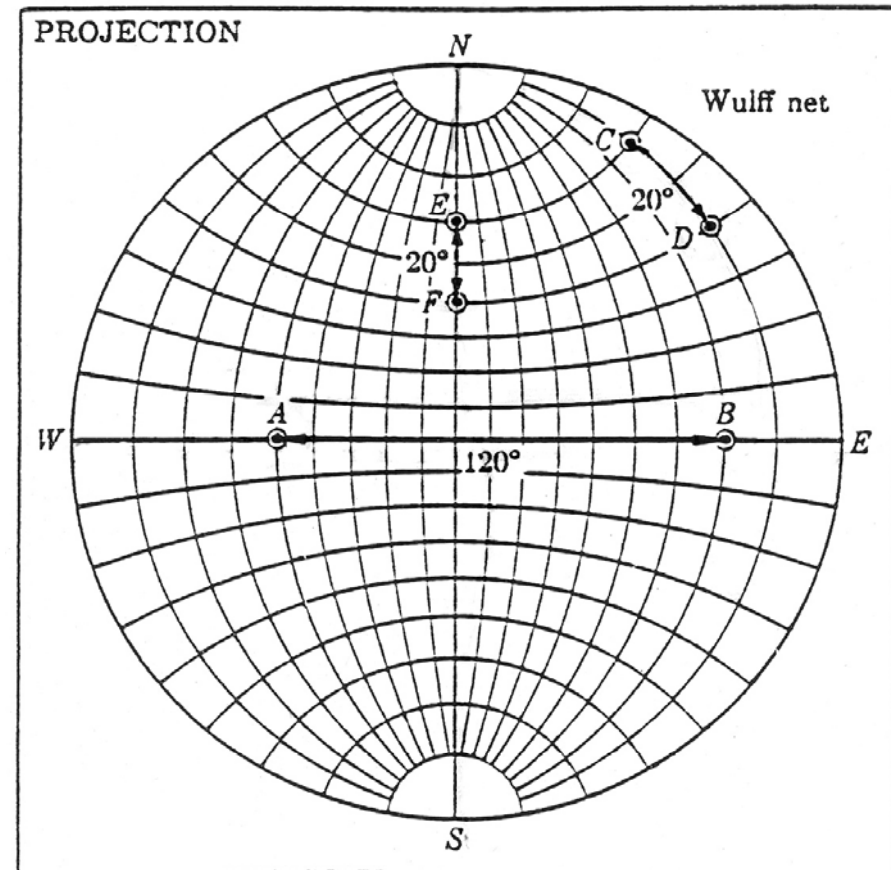
- “Only arcs of great circles are used when angles are plotted on or estimated from a stereographic projections”
- stereographic projection superimposed on Wulff net for measurement of angle between poles
- direct measurement along great circle



Angle between two planes

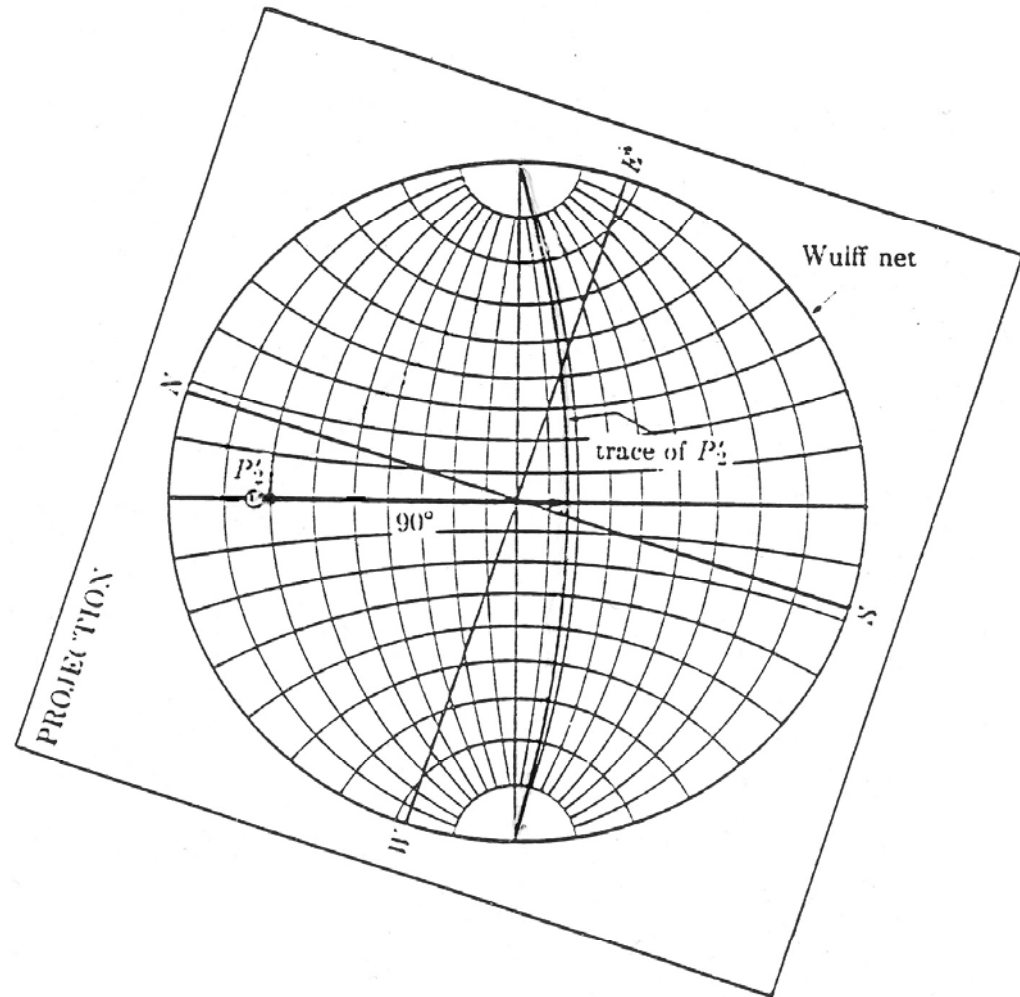
- Measurement of the angle between two crystal planes
- → if, and only if, the projected poles lie on a great circle.

Stereographic projection superimposed on Wulff net for measurement of angle between poles



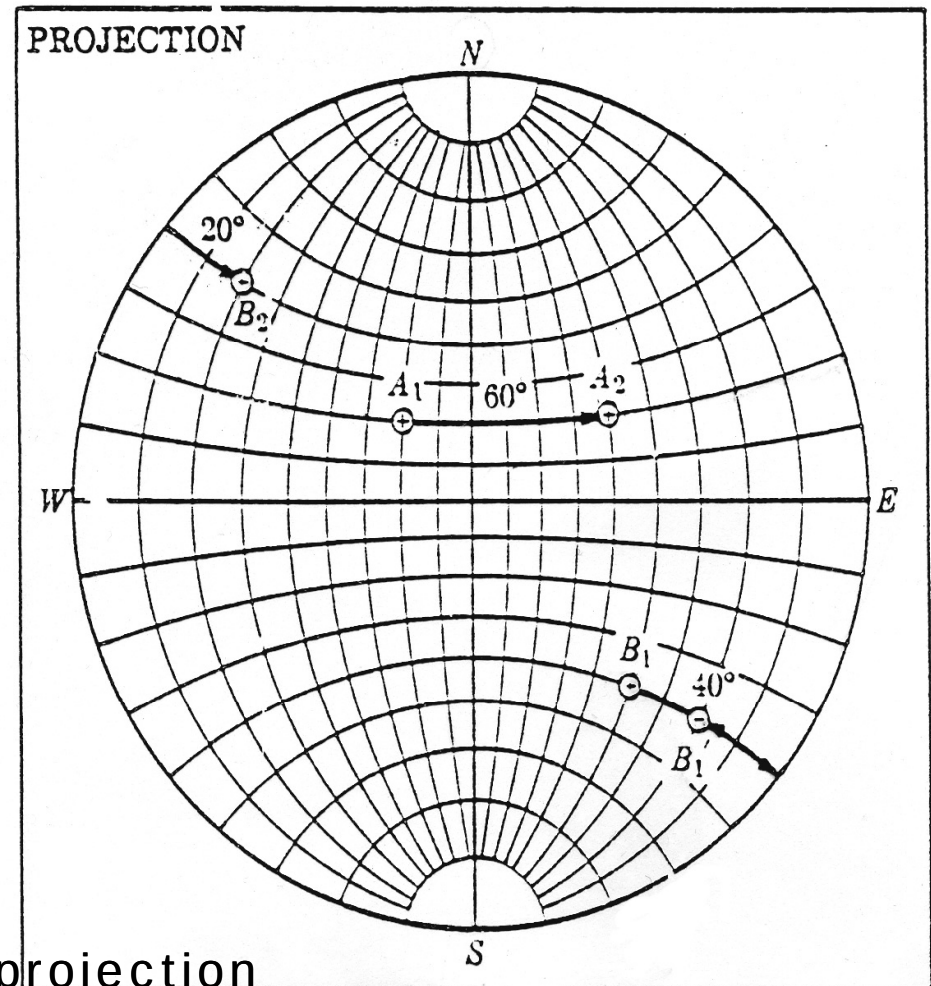
Trace of a plane

- Finding out the trace of a plane
- every point on this great circle is 90° from the pole of the plane.



Rotation of poles around axes

1. Rotation about an axes normal to the projection
2. Rotation about an axes lying in the plane of projection
 - a. rotating the axes to coincide with the N-S axis
 - b. moving the poles along their respective latitude circles

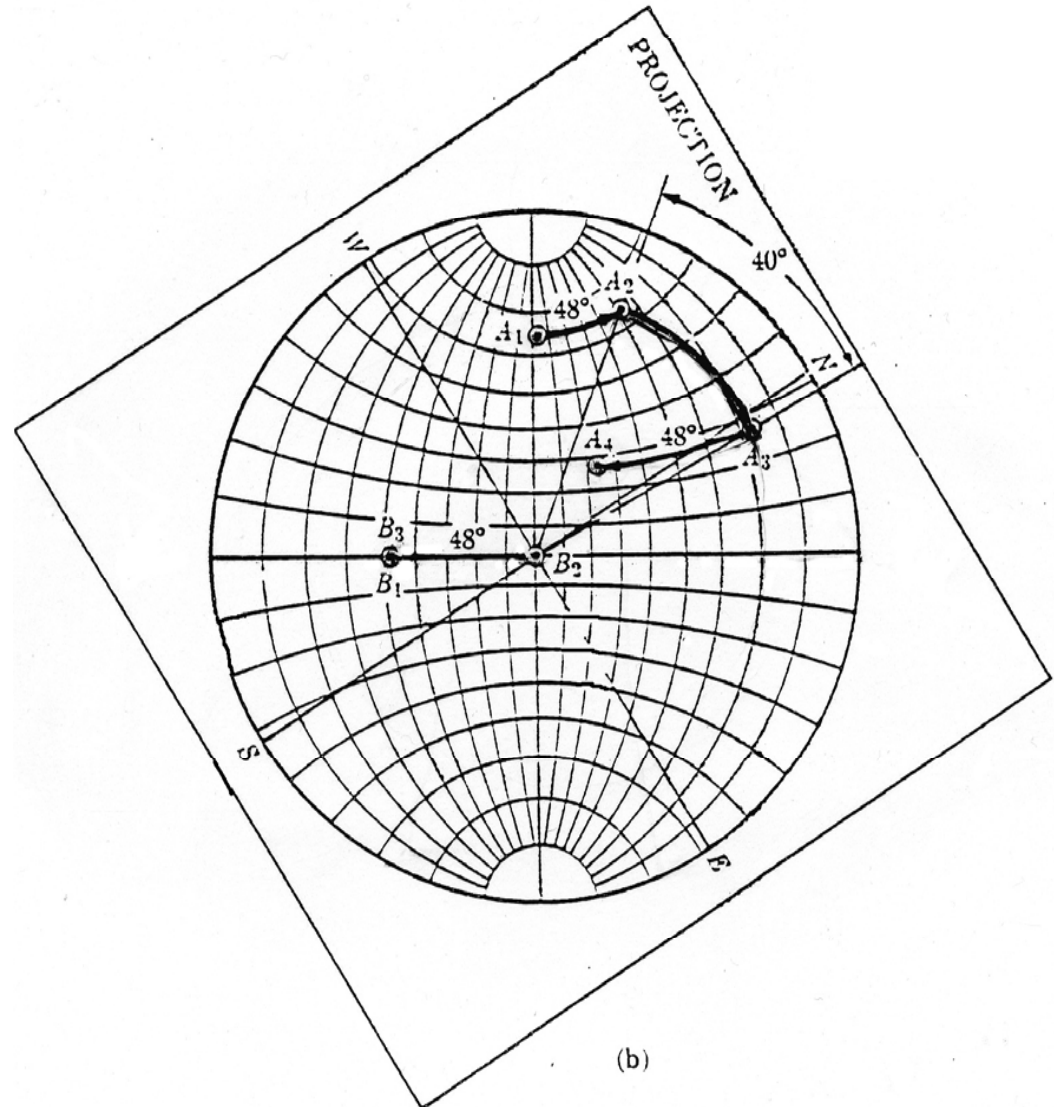


Rotation of poles about NS axis of projection

Rotation of poles around axes (cont.)

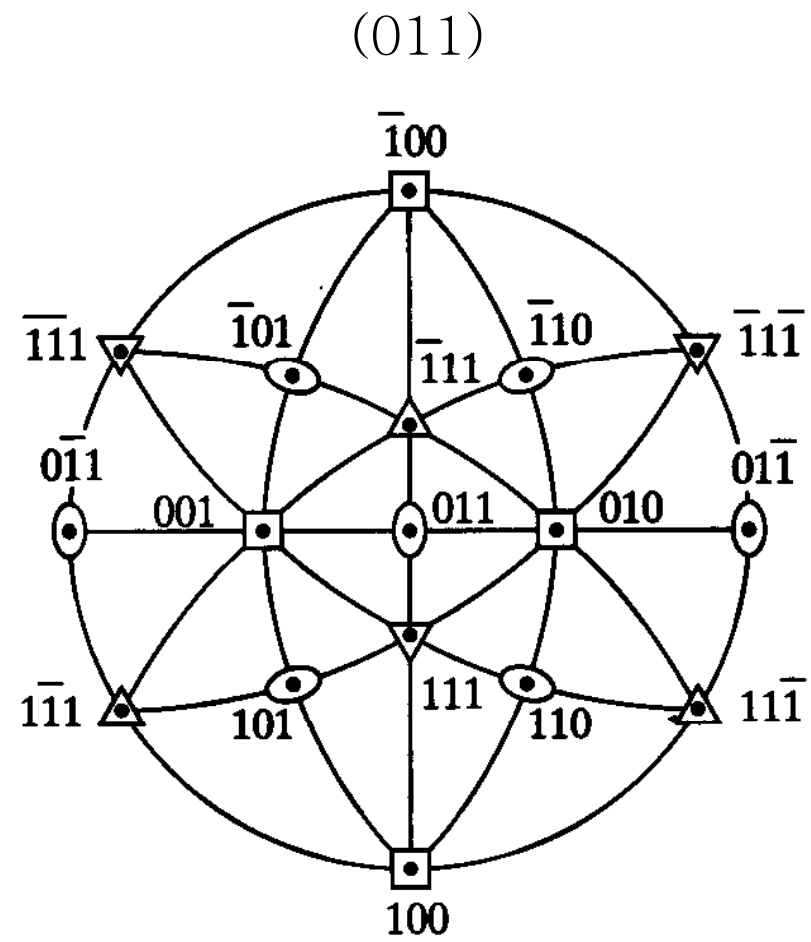
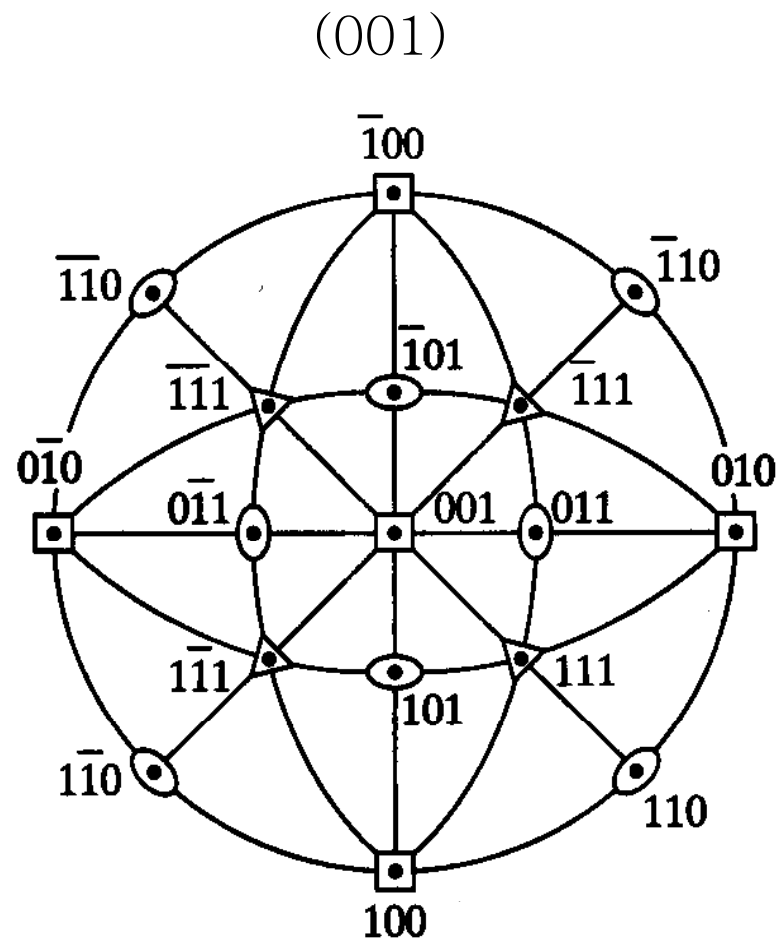
3. Rotation about an axis inclined to the plane of projection

- Example) Rotate the pole A around the pole B to 40° .
 - 1) Move the pole B to the center : $48^\circ \rightarrow (A_1 \rightarrow A_2)$
 - 2) Rotate 40°
 - 3) Move the pole B back to original position

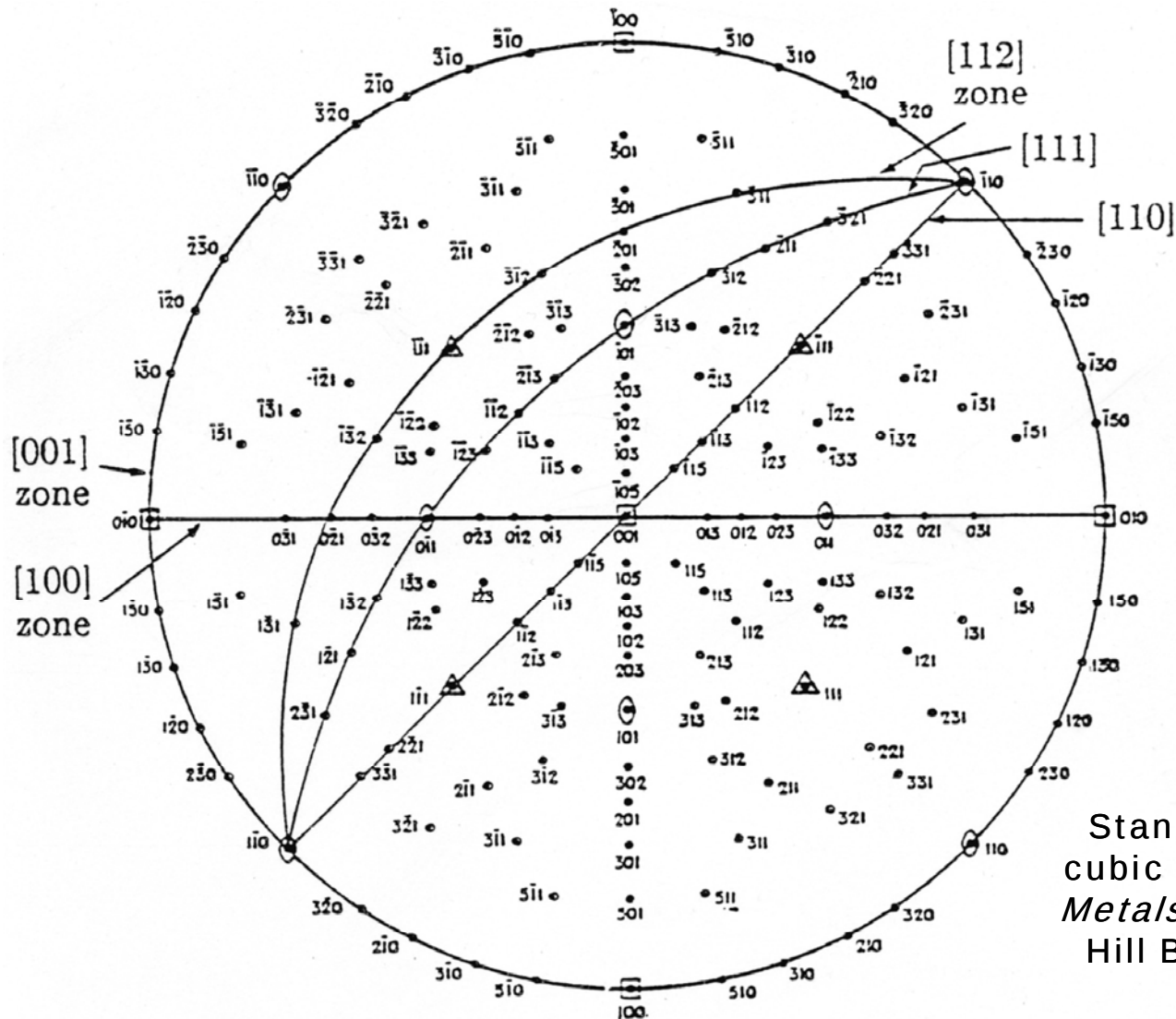


Stereographic Projections

- standard cubic stereographic projections



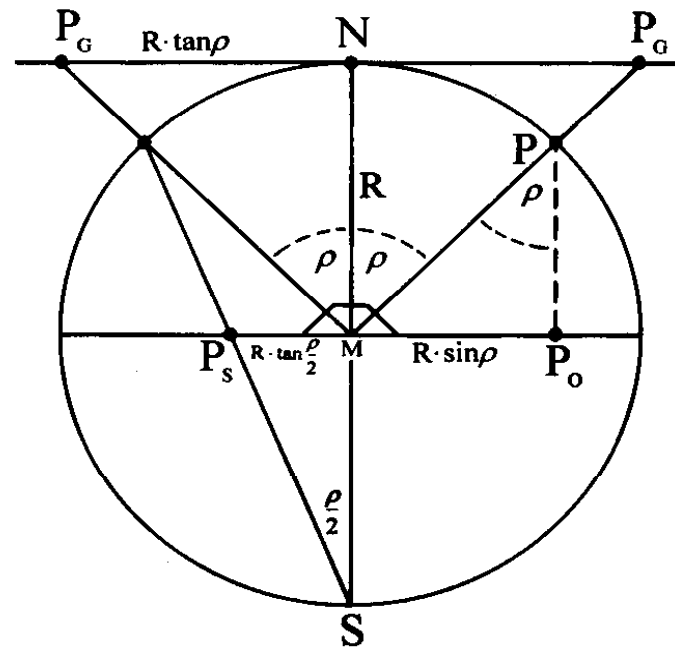
Standard projection (cubic)



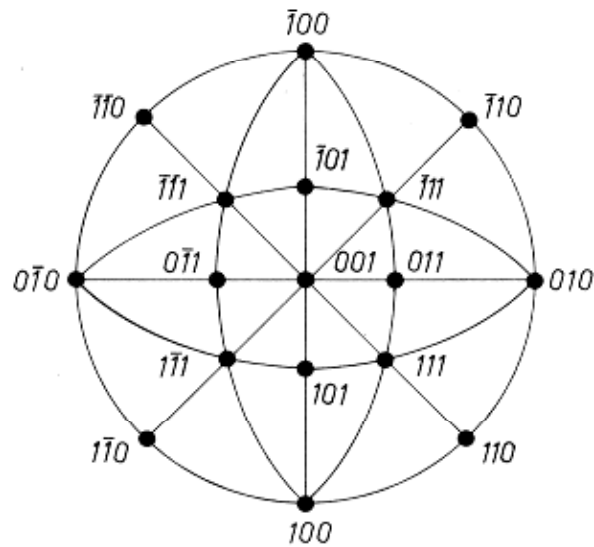
* 001, 011, 111 type
외 standard
projection 을 그리
고 [112] direction
이 나타나는 point
만 구하라.

Standard (001) projection of a
cubic crystal. (From *Structure of
Metals*, by C. S. Barrett, McGraw-
Hill Book Company, Inc., 1952)

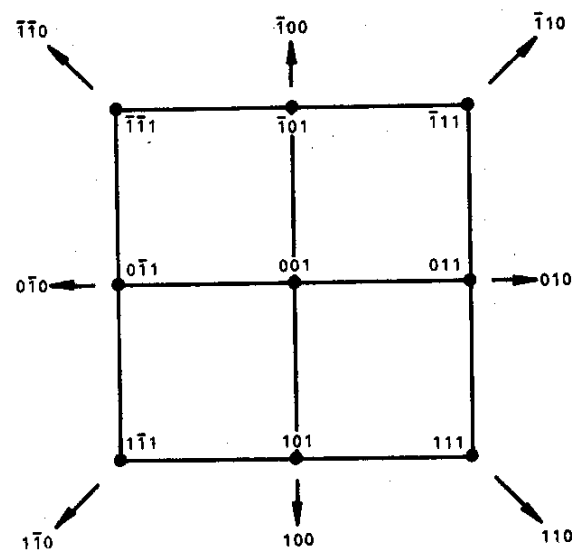
Projections



– stereographic



– gnomonic



– orthographic

