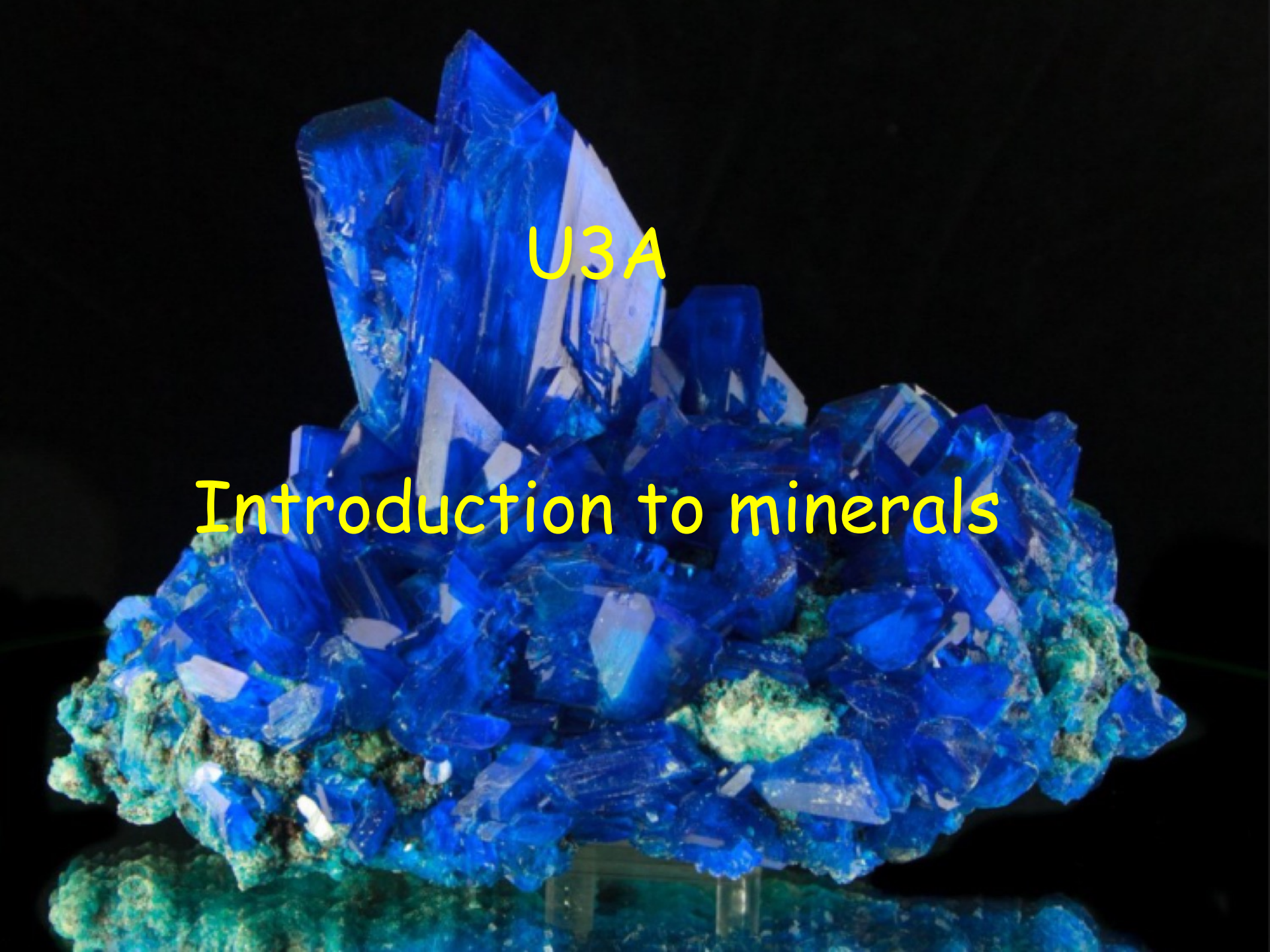


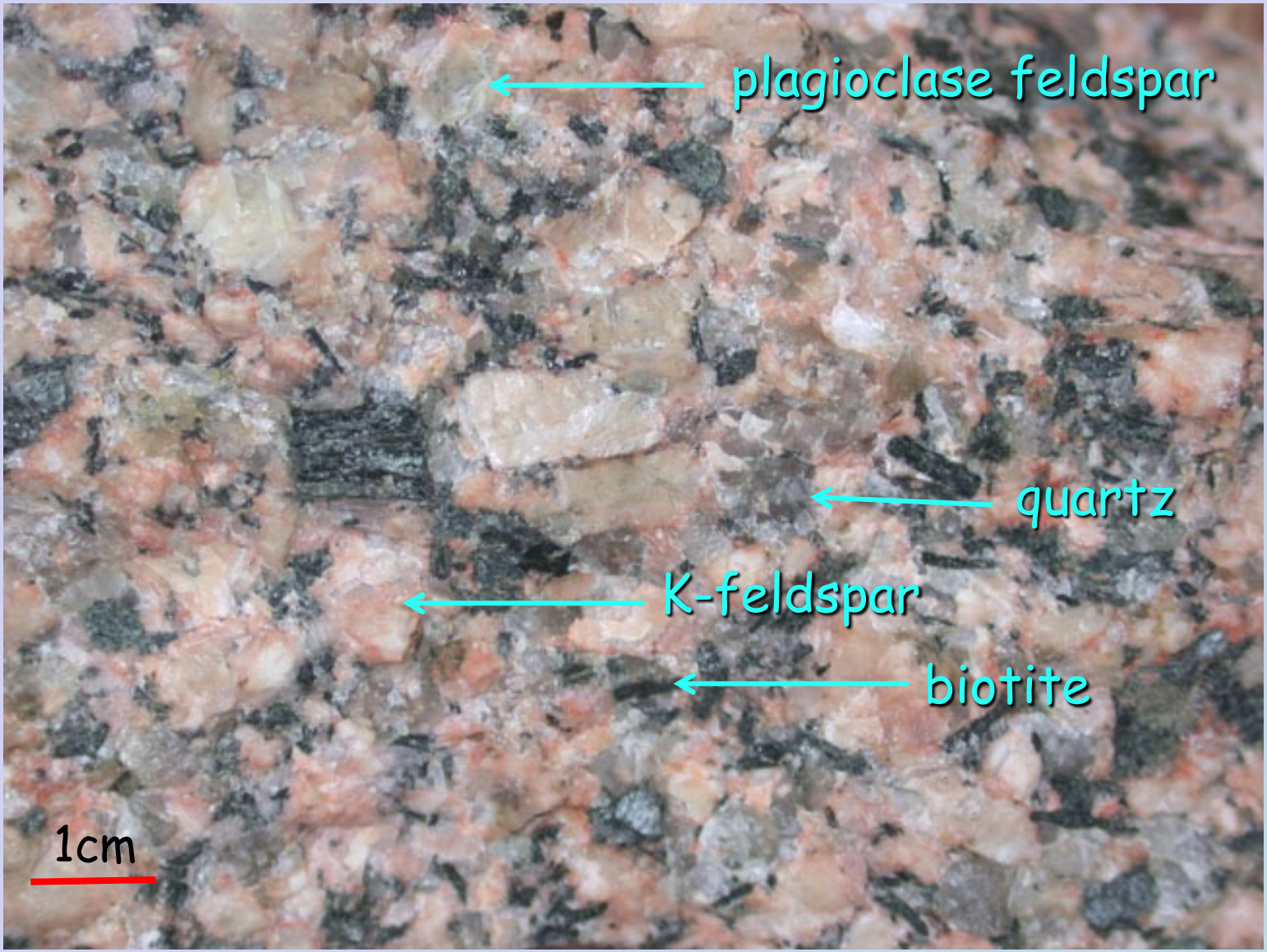
U3A

Introduction to minerals

Minerals and rocks

- Minerals – A mineral is a single entity with a defined chemical composition and structure

- Rocks - natural mixtures or aggregates of minerals (monomineralic rocks → one mineral)



Granite composed of four main minerals

Definition of a mineral

Minerals – A mineral is a (1) naturally occurring solid phase, possessing a (2) characteristic internal structure determined by a regular arrangement of the atoms and ions composing it, and (3) with a chemical composition and physical properties that are fixed or, that vary within definite ranges

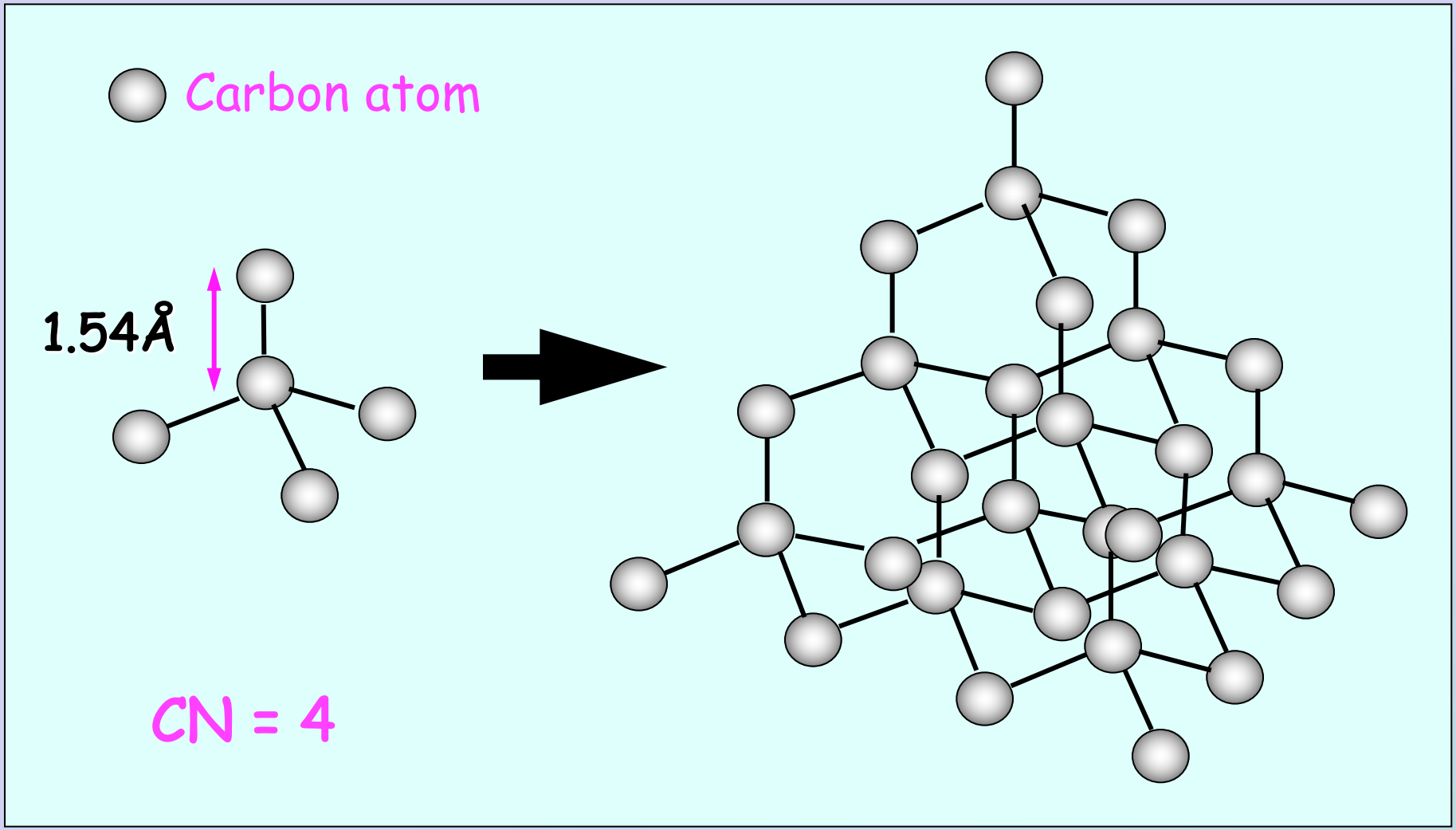
Polymorphism

- Polymorphism is where the same chemical compound can occur in two or more crystal structures depending on temperature and pressure of formation
- literally means 'many shapes'
- some examples are:
  - graphite and diamond (C)
  - calcite and aragonite ($CaCO_3$)
  - andalusite, kyanite and sillimanite (Al_2SiO_5)
- polymorphs have different physical properties, form under different environmental conditions

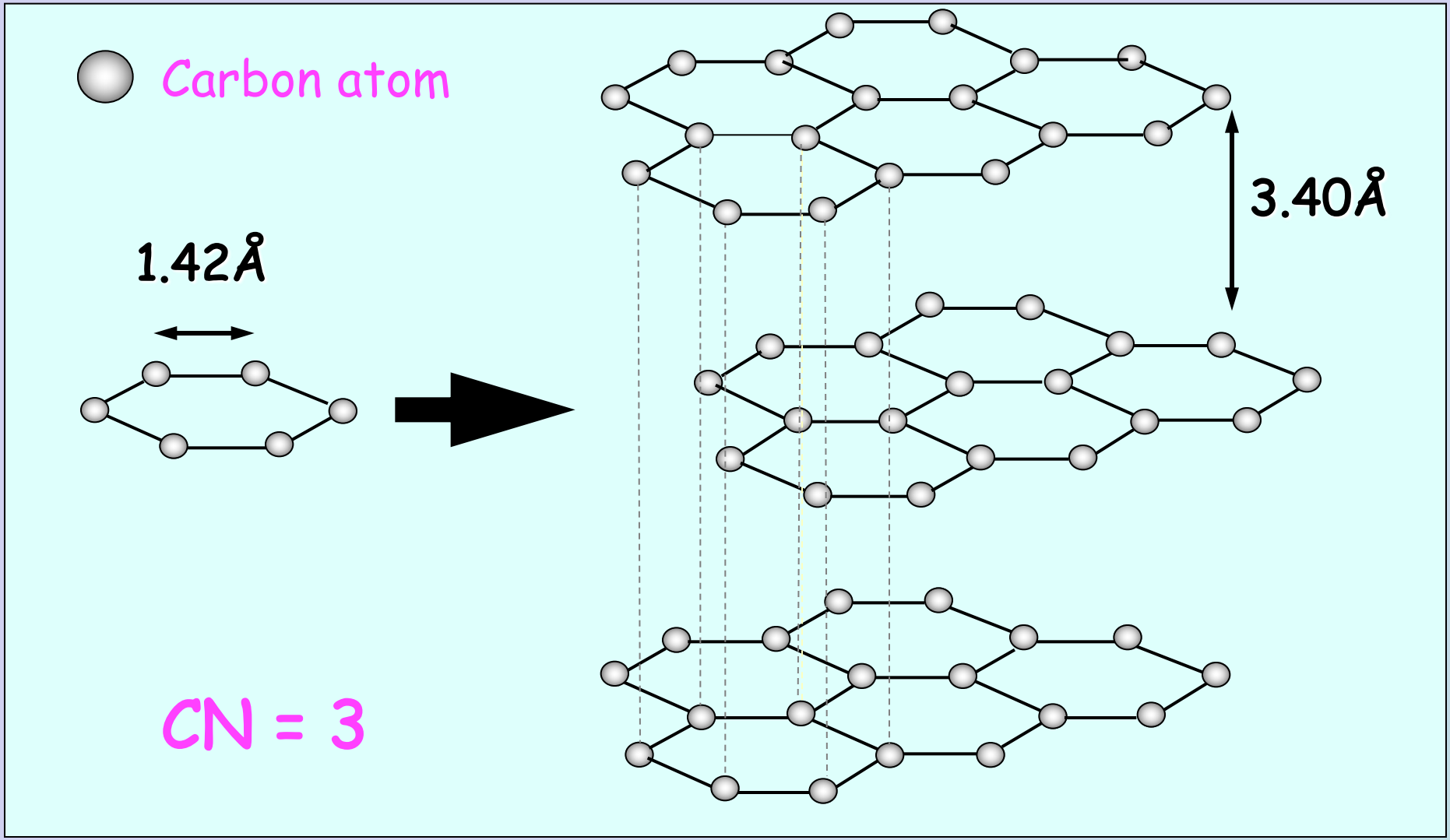
Polymorphs of carbon

	Diamond	Graphite
Crystal system	Cubic	Hexagonal
Crystal form	Octahedron	hexagonal flakes
Cleavge	Yes, octahedral	Yes, basal, like mica
Hardness	Hardest substance	one of the softest
Colour	Mainly colourless	Grey/black
Specific gravity	3.50	2.2

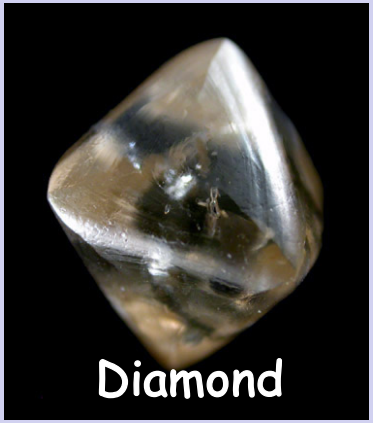
Diamond structure

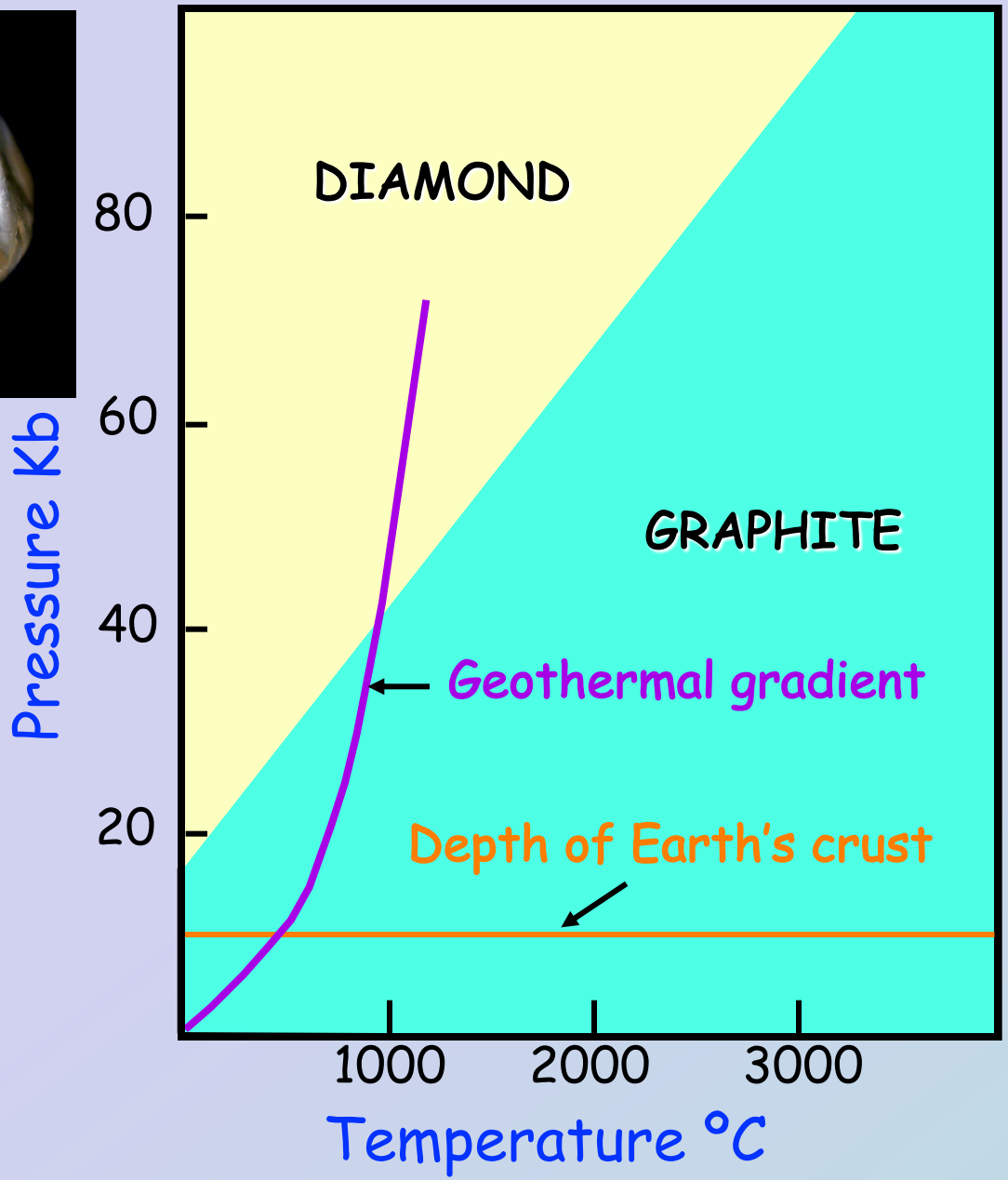


Graphite structure



Stability fields of carbon polymorphs





$CaCO_3$ polymorphs

Aragonite – $CaCO_3$
Orthorhombic
H = 3.5-4
S.G = 2.94
Cleavage: one plane

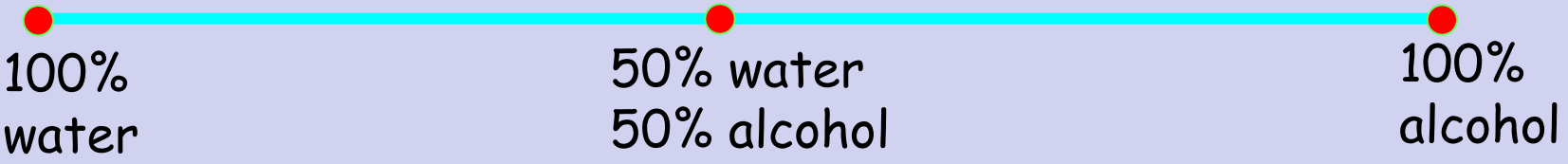
Calcite – $CaCO_3$
Trigonal
H = 3
S.G = 2.7
Cleavage: three planes

Definition of a mineral

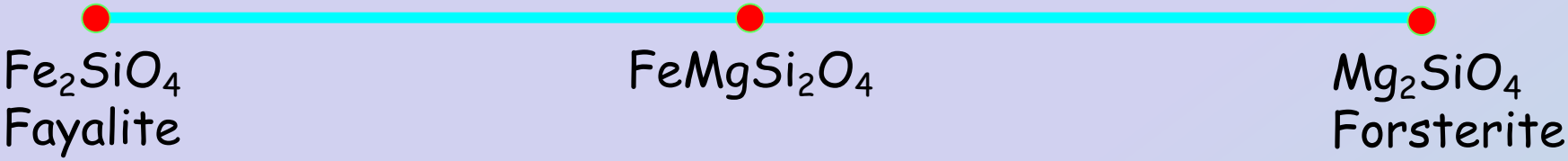
Minerals – a mineral is a naturally occurring solid phase, possessing a characteristic internal structure determined by a regular arrangement of the atoms and ions composing it, and with a chemical composition and physical properties that are fixed or, that vary within definite ranges

Continuous solution

Water and alcohol

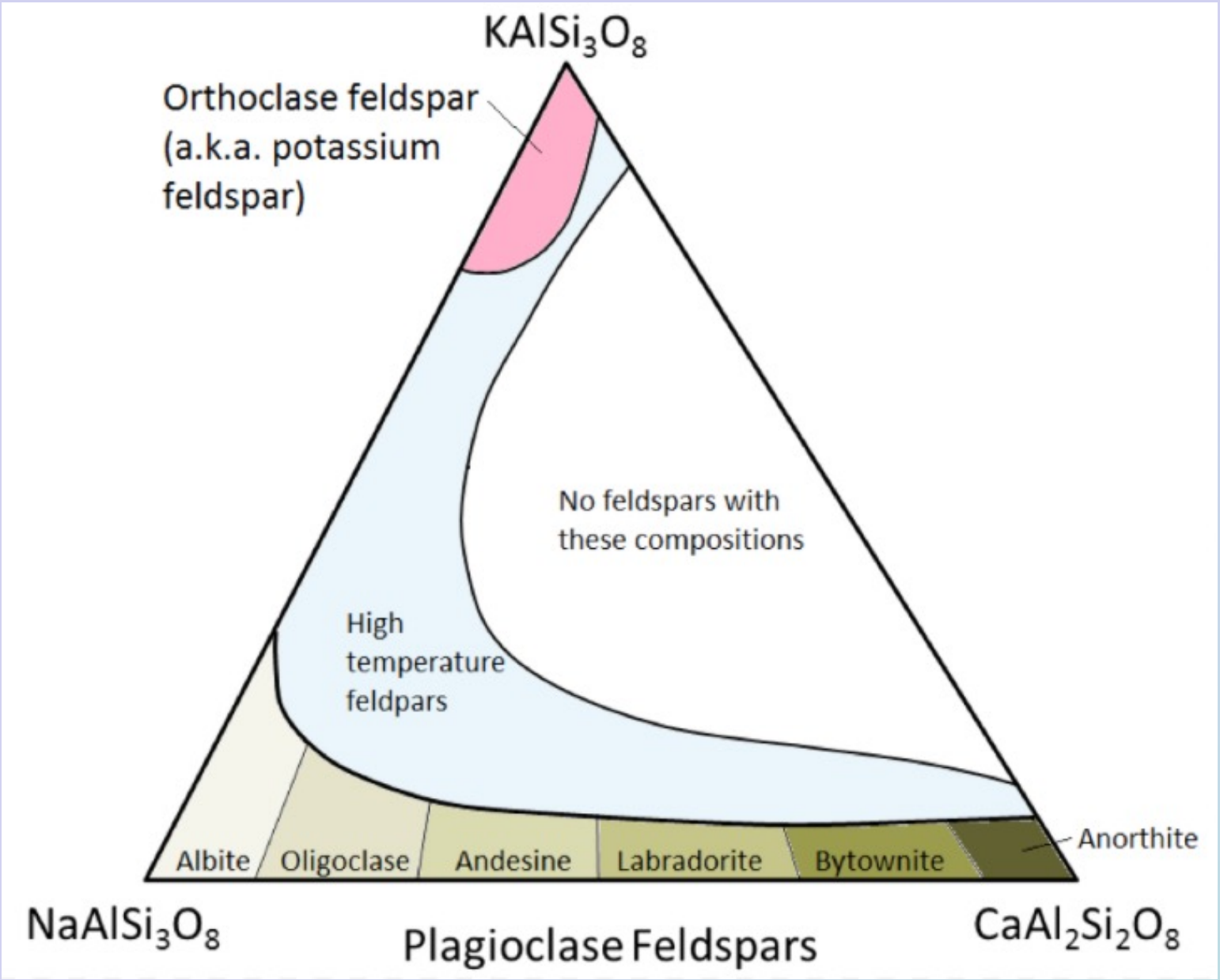


Olivine (solid solution)



Water and oil - non-continuous solution

Feldspar ternary diagram



Ionic substitution

e.g. muscovite

$KAl_2(Al,Si_3)O_{10}(OH)_2$

Na	Mg	F
Ba	Fe^{2+}	
Rb	Fe^{3+}	
Cs	Mn	
Ca	Li	
	Ti	
	Cr	

Minerals

- Minerals → are mostly crystalline with a regular atomic structure
  e.g. quartz, feldspar
- may sometimes be amorphous i.e. lacking crystalline structure
  e.g. opal, coronadite
- may be composed of one element but more commonly two or more elements
- are the major solid constituents of the Earth
- have various physical properties reflecting their composition and atomic structure

Octahedral crystals of fluorite (CaF_2)

Coronadite (lead manganese oxide) an example of an amorphous mineral

Rhodonite ($MnSiO_3$) and galena (PbS), Broken Hill NSW

Minerals in the Earth's crust

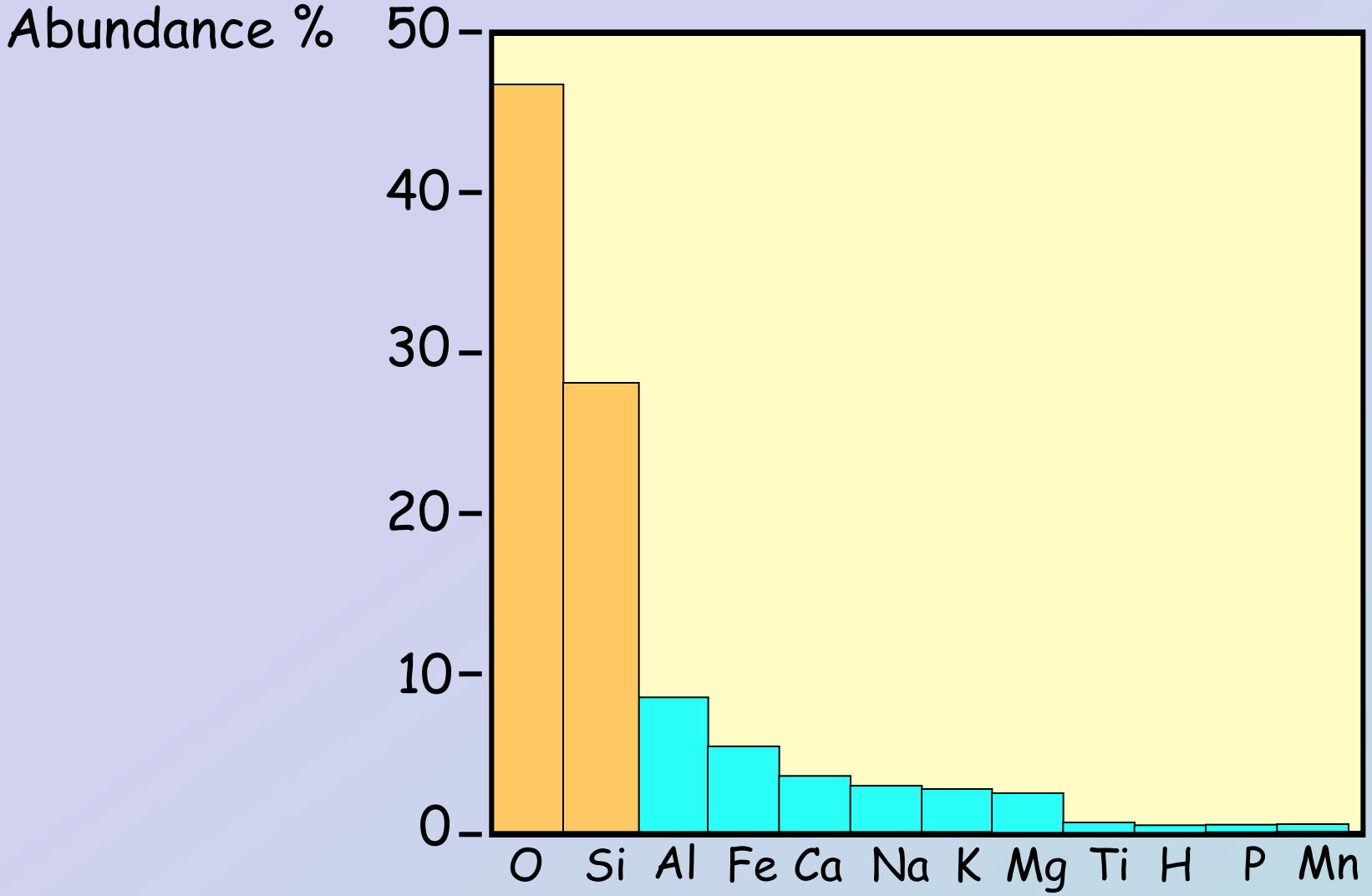
- About 3000 minerals are known → only 10 make up 99% of the Earth's crust
- new minerals are described every year
- most common elements in rocks are:

  oxygen (47%)

  silicon (28%)

  together making up 75% of the Earth's crust
- silicates are the most common minerals and compose 95% of the Earth's crust

Most abundant elements



Most abundant minerals in the Earth's crust

1.	Plagioclase feldspar*	42%	$CaAl_2Si_2O_8.NaAlSi_3O_8$
2.	Potassium feldspar*	22%	$KAlSi_3O_8$
3.	Quartz*	18%	SiO_2
4.	Amphibole*	5%	$Ca_2(AlFeMg)_5(Si,Al)_8O_{22}(OH)_2$
5.	Pyroxene*	4%	$(CaMgFe)SiO_3$
6.	Mica*	4%	$K(MgFeAl)_3(SiAl)_4O_{10}(OH)_2$
7.	Magnetite-ilmenite	2%	Fe_2O_3-FeO,TiO_2
8.	Olivine*	1.2%	$(Mg,Fe)_2SiO_4$
9.	Apatite	0.4%	$Ca_5(PO_4)_3(OH,F,Cl)$
10.	Calcite	0.4%	CaCO3
		99%	*Silicate

Physical properties of minerals 1

Crystal form

- the characteristic shape of a crystal
- reflects the internal arrangement of atoms

Cleavage

- the tendency for a mineral to preferentially split along a particular plane
- cleavage occurs along weak bonds in the lattice

Fracture

- how a mineral breaks when it has no planes of weakness
- e.g. quartz has a conchoidal fracture

Apatite crystal

Physical properties of minerals 1

Crystal form

- the characteristic shape of a crystal
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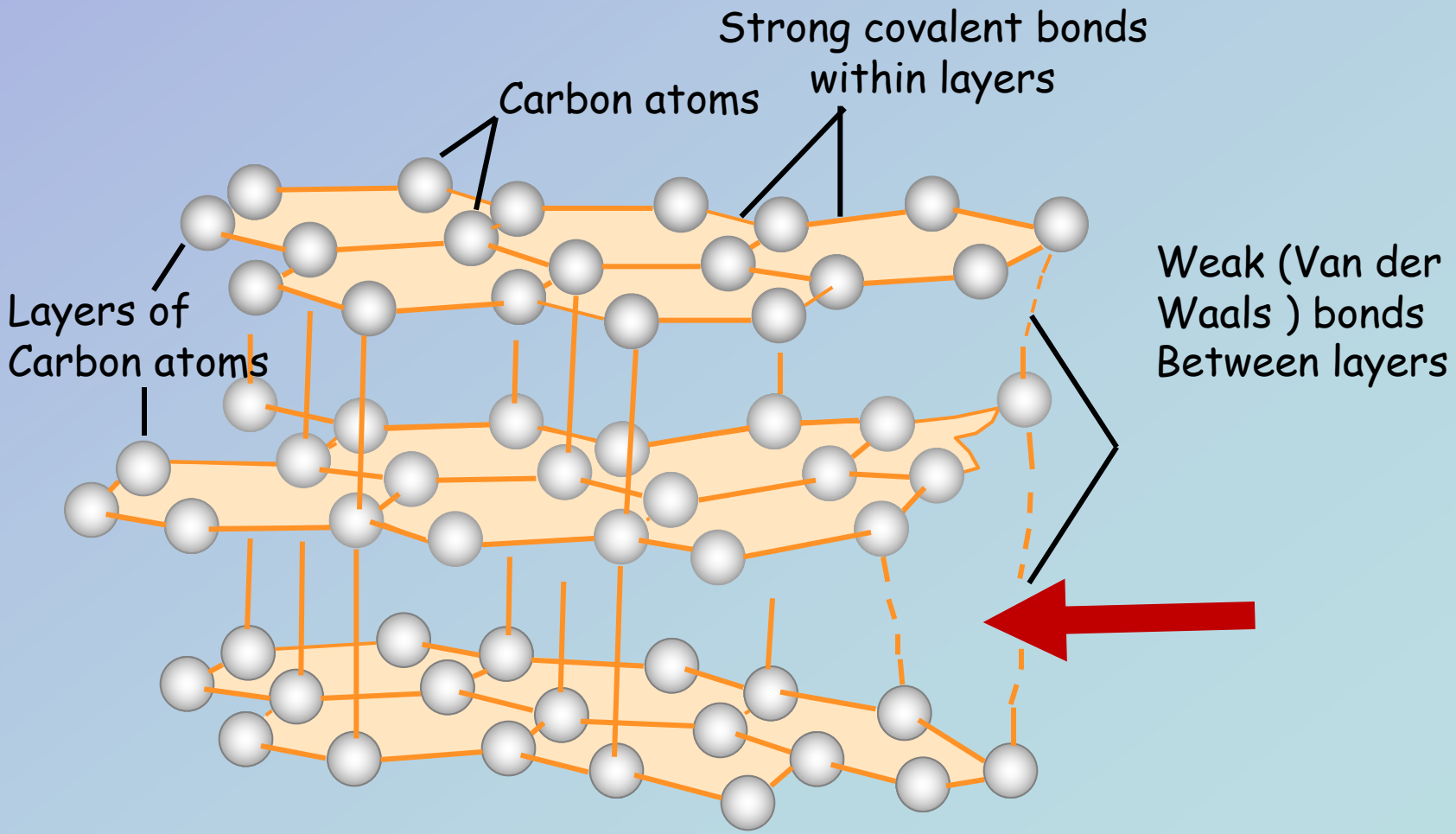
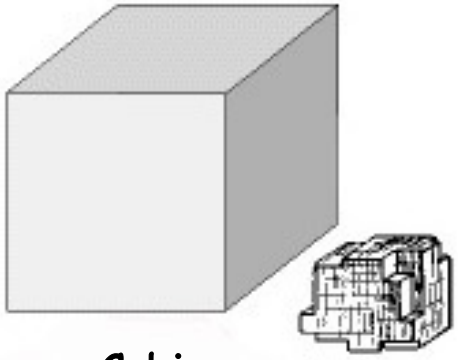
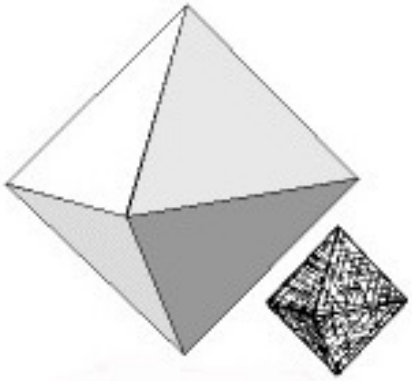
Development of cleavage in graphite



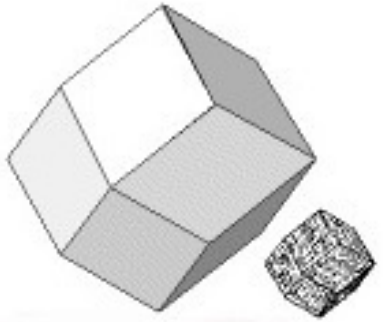
Cleavage



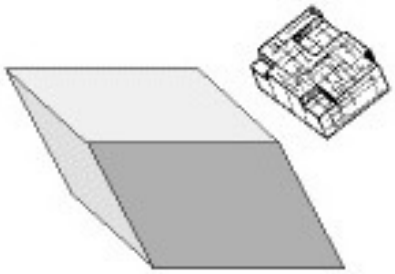
Cubic
3 cleavages at right angles e.g.halite



Octahedral
4 cleavages e.g. fluorite



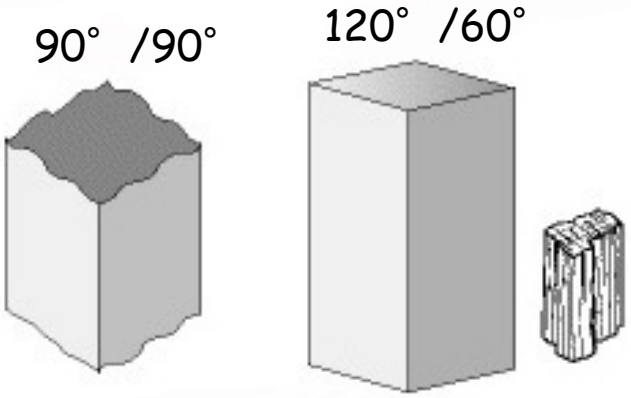
Dodecahedral
6 cleavages e.g. sphalerite



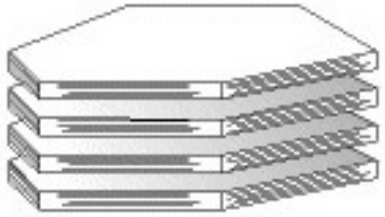
Rhombohedral
3 cleavages not at right angles e.g. calcite

90° /90°

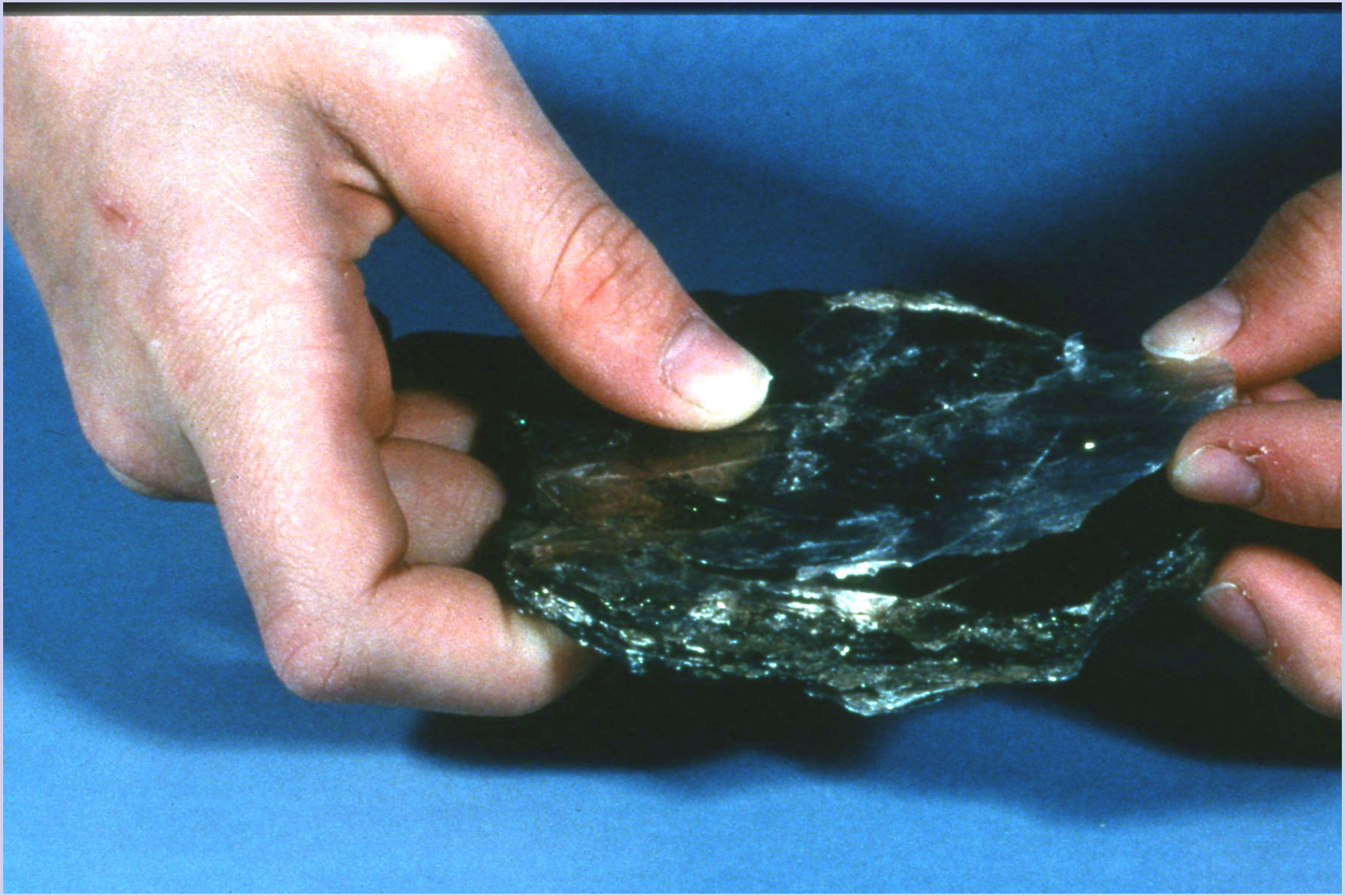
120° /60°



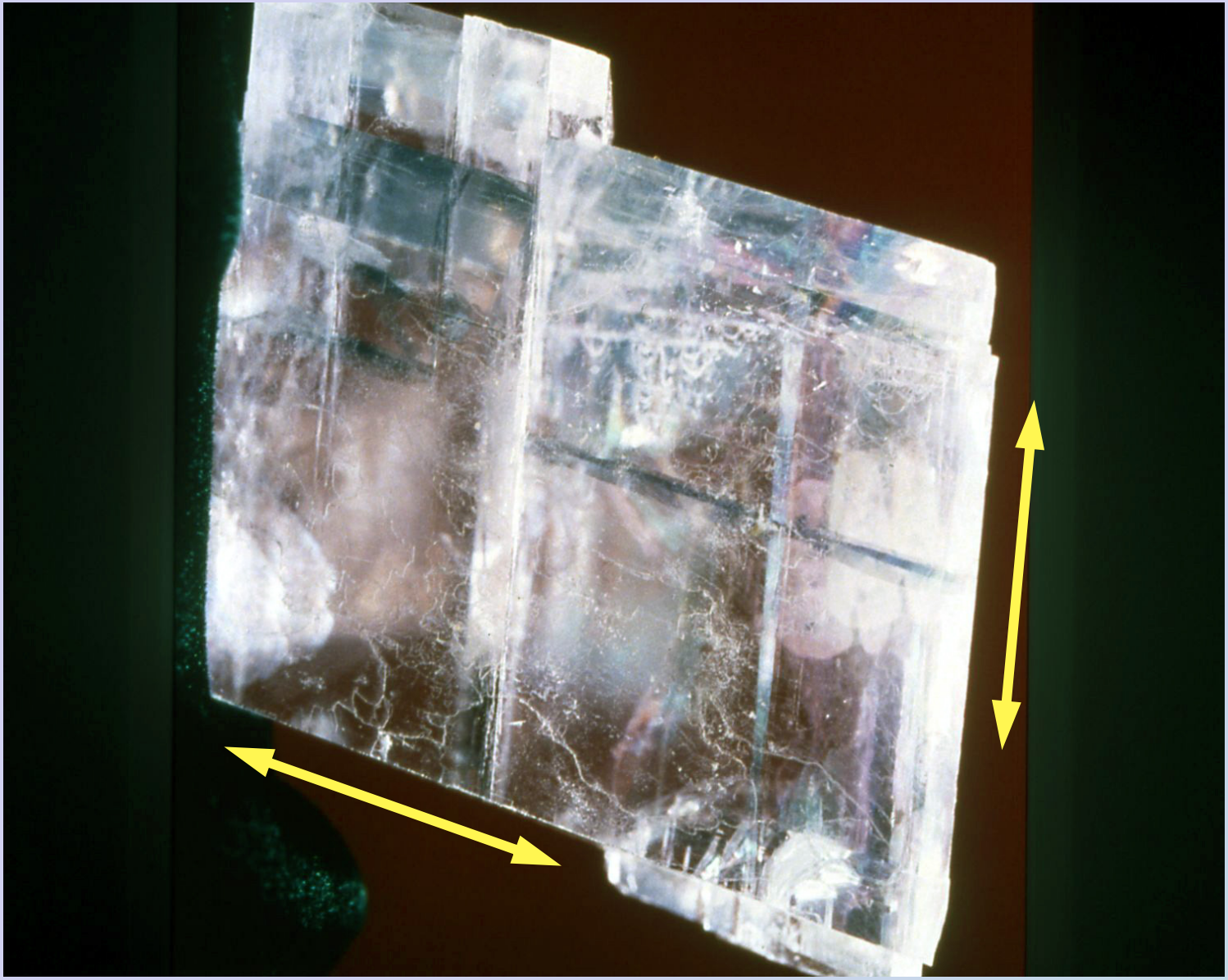
Prismatic
2 cleavages @ 90°
2 cleavages @ 60° /120°



Basal
One single cleavage
e.g. muscovite



Perfect cleavage in the mica mineral biotite



Rhombohedral cleavage in calcite

Conchoidal fracture in quartz

Physical properties of minerals 2

Hardness

- the resistance of a mineral to scratching
- reflects the overall strength of atomic bonds

Density

- the mass per unit volume of the mineral
- controlled by atomic species present and
  especially how close atoms and ions are spaced

Lustre

- general way that the mineral surface reflects light
- simple division into metallic and non-metallic
- varying degrees of non-metallic lustre

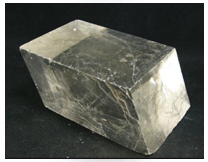
Mohs' hardness scale

1 - TALC - 1

2 - GYPSUM - 2

fingernail - - - - -

3 - CALCITE - 9



copper coin - - - -

4 - FLUORITE - 21

5 - APATITE - 48

knife blade - - - -

6 - FELDSPAR - 72

7 - QUARTZ - 100

8 - TOPAZ - 200

9 - CORUNDUM - 400

10 - DIAMOND - 1600

Blue = Vickers hardness

* Note that the scale is not linear

Physical properties of minerals 2

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- reflects the overall strength of atomic bonds

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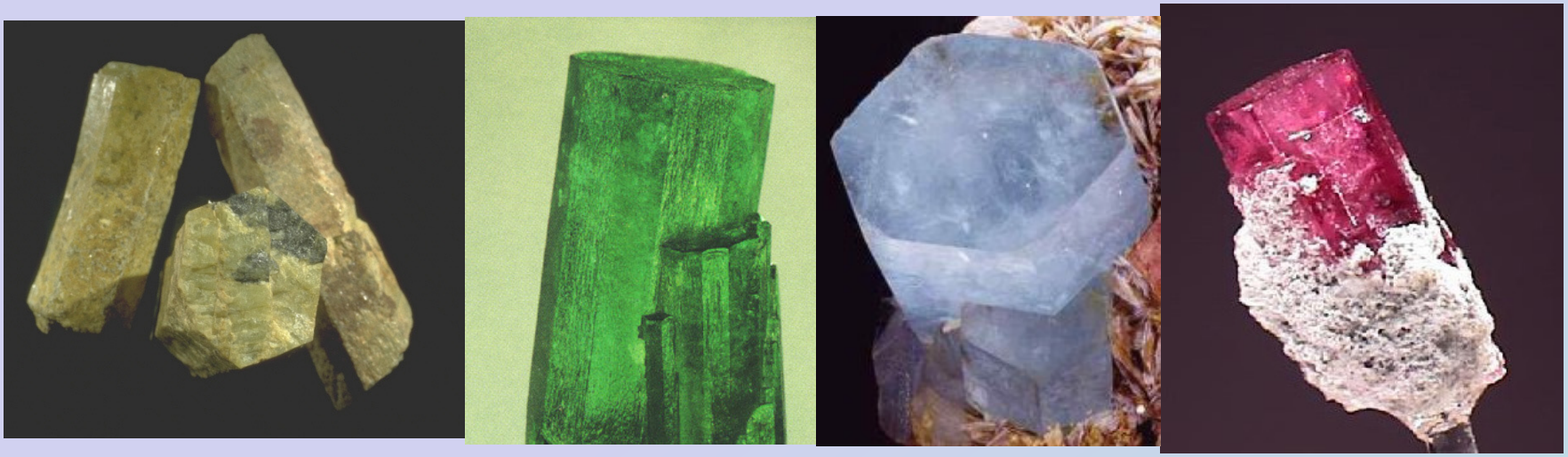
Physical properties of minerals 3

Colour and streak

- an obvious but variable property of a mineral
- controlled by small variations in the composition
- the streak is usually more diagnostic



Colour varieties of the mineral beryl $Be_3Al_2Si_6O_{18}$

Slice through watermelon tourmaline crystal

Streak

Colour of powdered mineral on ceramic plate

Habit

Habit refers to the way in which individual crystals or aggregates of crystals occur

massive

acicular

botryoidal

tabular

radiating

Columnar/prismatic

pisolitic

platy

drusy

Significance of silicates

- Most abundant minerals in the Earth's crust and mantle
- silicate rocks host many important ore deposits
- they have significant direct industrial uses, e.g.
  - ceramics
  - abrasives
  - sand & building materials
- silicates give information on thev physical conditions of formation of their host rocks

Silicate groups

Nesosilicates (orthosilicates, island silicates)

Sorosilicates (disilicates)

Cyclosilicates (ring silicates)

Inosilicates (chain silicates) – single chain

-- double chain

Phyllosilicates (sheet silicates)

Tectosilicates (framework silicates)

Non-silicate mineral groups

Oxides e.g. magnetite (Fe_3O_4), rutile (TiO_2), cassiterite (SnO_2)

Hydroxides e.g. brucite [$Mg(OH)_2$], goethite [$FeO(OH)$]

Carbonates e.g. calcite ($CaCO_3$), siderite ($FeCO_3$)

Native elements e.g.gold (Au), diamond (C), bismuth (Bi)

Sulphides e.g. pyrite (FeS_2), chalcopyrite ($CuFeS_2$)

Sulphates e.g. barite ($BaSO_4$), anglesite ($PbSO_4$)

Halides e.g. halite (NaCl), fluorite (CaF_2)

Other groups include borates, arsenates, phosphates, nitrates etc.