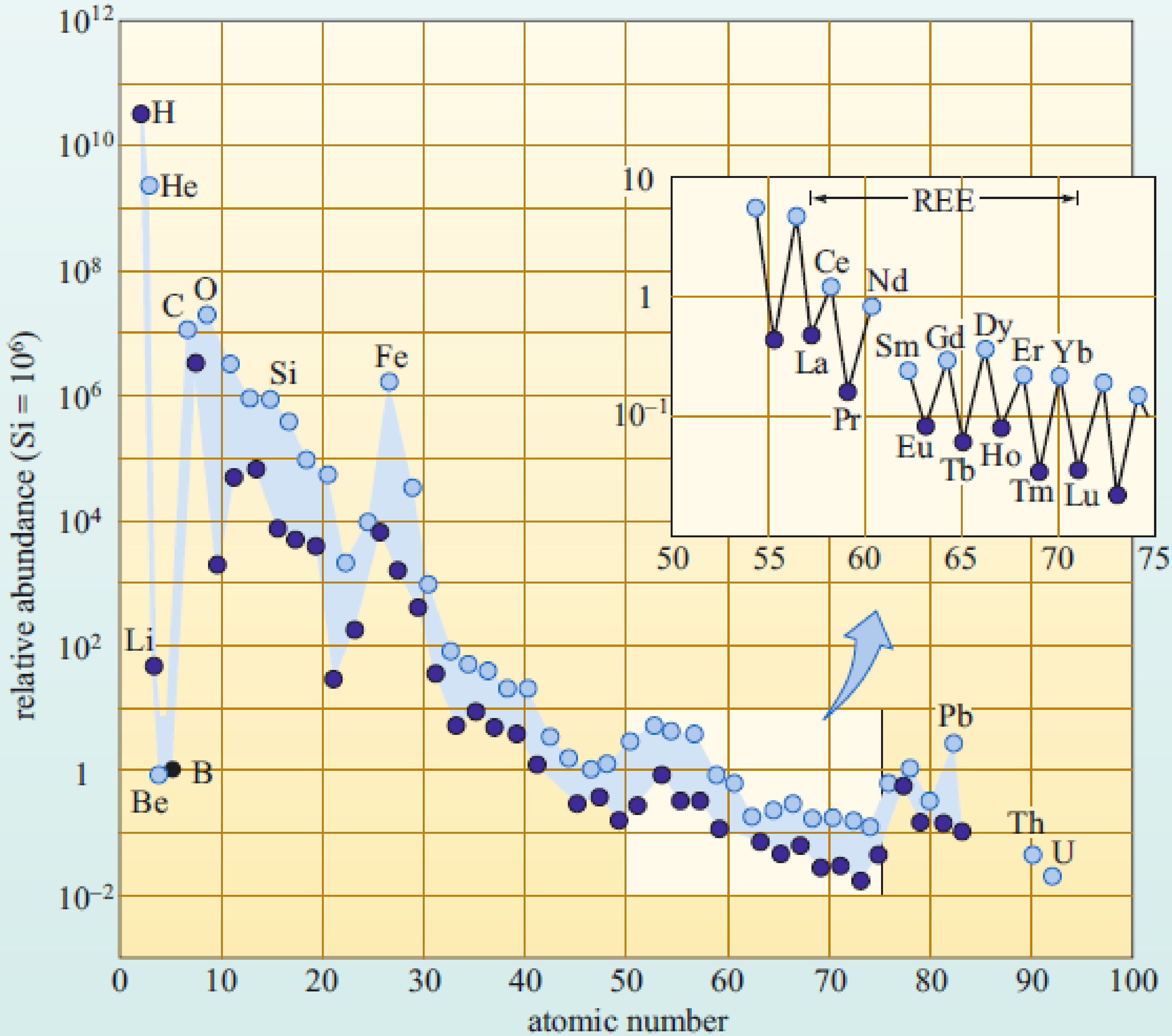
The SUN

-Study of electromagnetic radiation to study SUN
-SUN Atmosphere, different chemical elements absorb radiation at specific wavelengths.
By this Astronomers gain knowledge of the compositions of the distant stars and galaxies.

Amount of light absorbed is proportional to the amount of an element present in the Sun's atmosphere ...

No absolute abundance but relative....in our case, we see this
In a plot, relative to a nominal abundance of Silicon,,,10*6 atoms.



relative abundance (Si = 10^6)
atomic number
10^{12}
10^{10}
10^8
10^6
10^4
10^2
1
10^{-2}
0
10
20
30
40
50
60
70
80
90
100
H
He
Li
Be
B
C
O
Si
Fe
Pb
Th
U
REE
10
1
10^{-1}
50
55
60
65
70
75
Ce
Nd
La
Pr
Sm
Gd
Dy
Er
Yb
Eu
Tb
Ho
Tm
Lu

See the abundance of Fe and Pb,,,
Both are extracted from the ore bodies by industrial processes,
Fe is ~1,000,000 times abundant in the SUN than Pb.
Au (Gold; 79) and Pt (Platinum; 78) are comparable to Pb, but
Au and Pt are regarded as being much rarer and of greater value.

Why Pb more abundant in the Earth than the precious metals?

Earth's crust formation and its composition is due to many processes since planetary accretion.

Different Elements have different geochemical properties and so respond in contrasting ways during geological and planetary processes.
Pb has concentrated more in crust while Fe in Mantle and core.

Elements condensation from the solar nebula

Solar nebula...hot to start...cooled slowly

Different chemical elements gradually condensed according to their individual volatilities.

Many elements have boiling point much higher to be considered Significantly in our everyday experience. However in a very low Pressure condition of nebula, difference in their boiling points Becomes important.

For example- Al2O3 (Alumina) has vaporisation temperature 3500 K under atmospheric conditions (10*5 N/sq. Meter), but in the lower pressures of the Solar nebula (10 N/sq. Meter), it reduces to 1700 K.

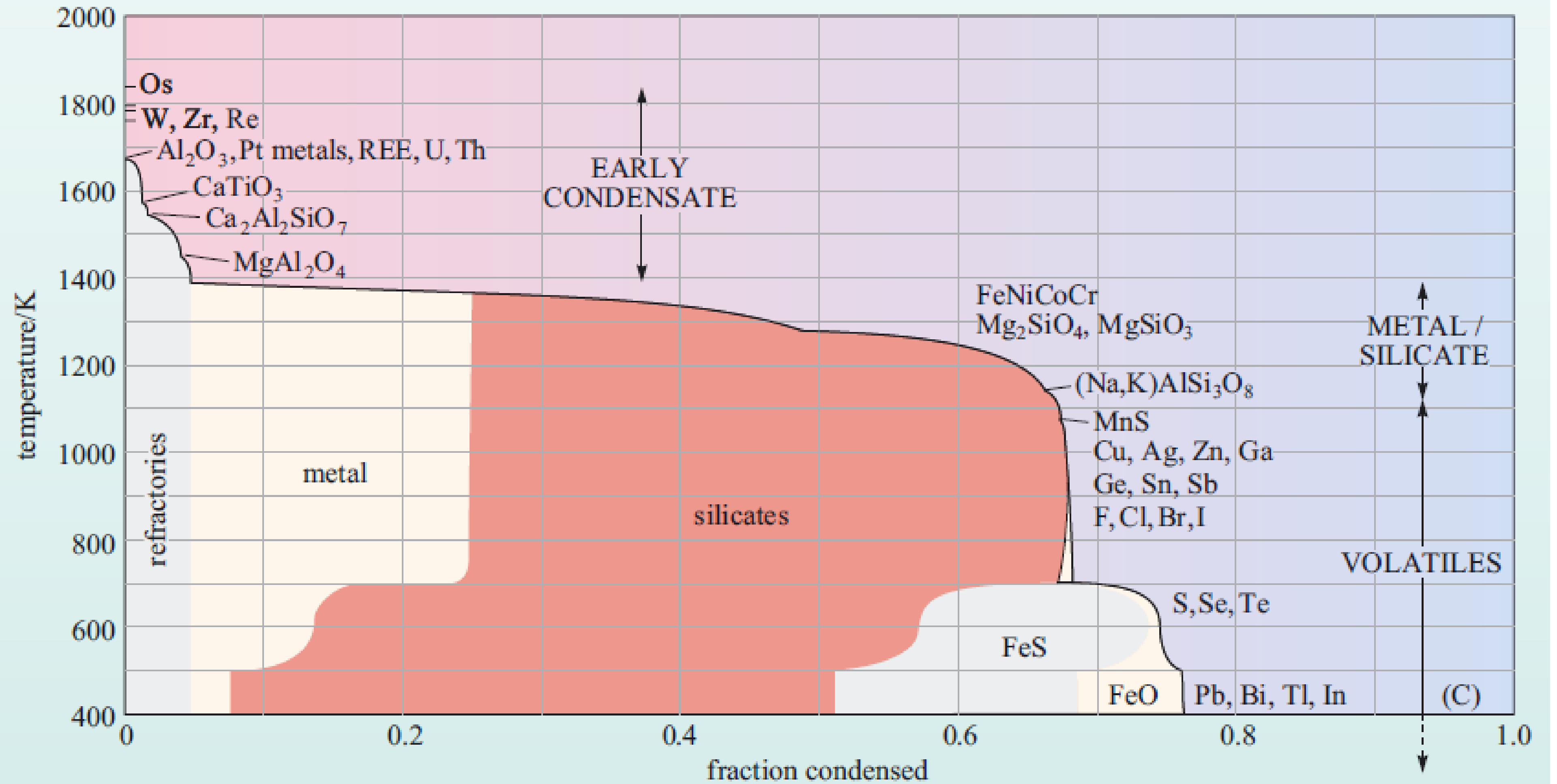


Figure 1.16 The condensation sequence of the solar nebula at a pressure of about 10 N m^{-2}. The *x*-axis represents the fraction of the nebula that has condensed at the temperature given on the *y*-axis. The curve is annotated to show which elements and compounds condense at which temperatures. At this low pressure, all materials condense from gases to solids directly without an intervening liquid phase. (K = kelvin = T °C + 273) (Morgan and Anders, 1980)

What are the proportions of the dominant components of the condensate?

The early condensates, or refractories, comprise 5% of the total. This is followed by metals, which comprise 20% of the total, and silicates, which comprise 40% of the total. The remainder includes volatiles and ices. The condensate is dominated by silicates and metals.

If the temperature in the solar nebula decreased outwards from the proto-Sun, can you suggest a mechanism that might have produced the terrestrial planets (Mercury, Venus, Earth and Mars) and gas giant planets (Jupiter, Saturn, Uranus and Neptune)?

Given the sequence of condensation in Figure 1.16, then volatile elements and ices would only condense when the temperature of the solar nebula dropped below 300 K. Perhaps such cold conditions only occurred beyond the orbit of Mars.

Meteororites

Second source of information of Solar system

They contain material thought to be representative of the early solar nebula.

Mostly derived from asteroid belt, possibly planetary embryos
Probably resulted from gravitational disturbances caused by Jupiter, perturbing the orbits of individual asteroids and causing repeated violent collisions that resulted in further fragmentation rather than accretion.

Meteorites come in a variety of compositions, but can be broadly classified into-

Stony meteorites, dominant of silicate minerals

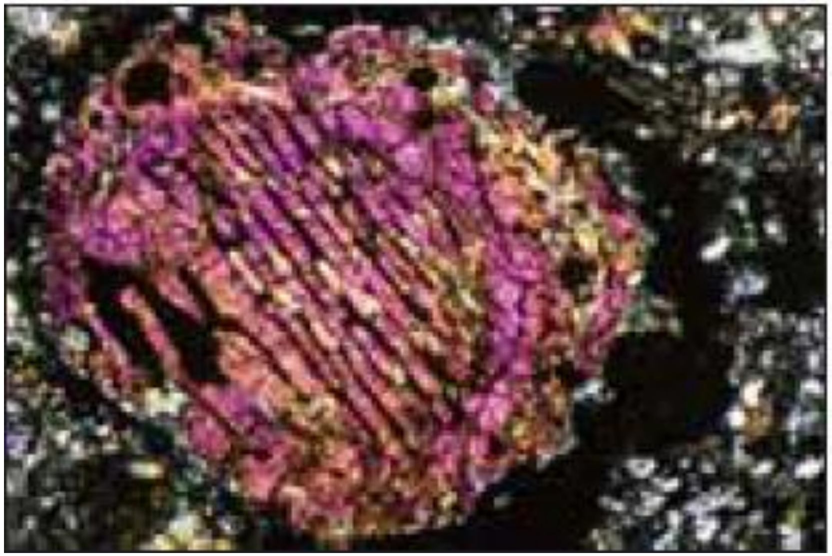
Iron meteorites, primarily composed of metallic iron

Stony-iron meteorites, a hybrid of the other two.

Iron and stony-iron meteorites have undergone an amount of chemical processing described as **“Differentiated”**
- Enrichment of Fe and Ni due to removal of some or all of the silicate minerals

Stony meteorites account for up to 95% of all known meteorite falls and are subdivided into **chondrites** and **achondrites**, depending on whether they contain **chondrules** or not. Chondrules are small, roughly spherical globules of silicate minerals of 0.1-2mm in size.

Shape and crystallinity suggest that they were once molten in a low gravitational field, indicating that they formed away from major planetary bodies, either on the surface of planetesimals or or even within the solar nebula.



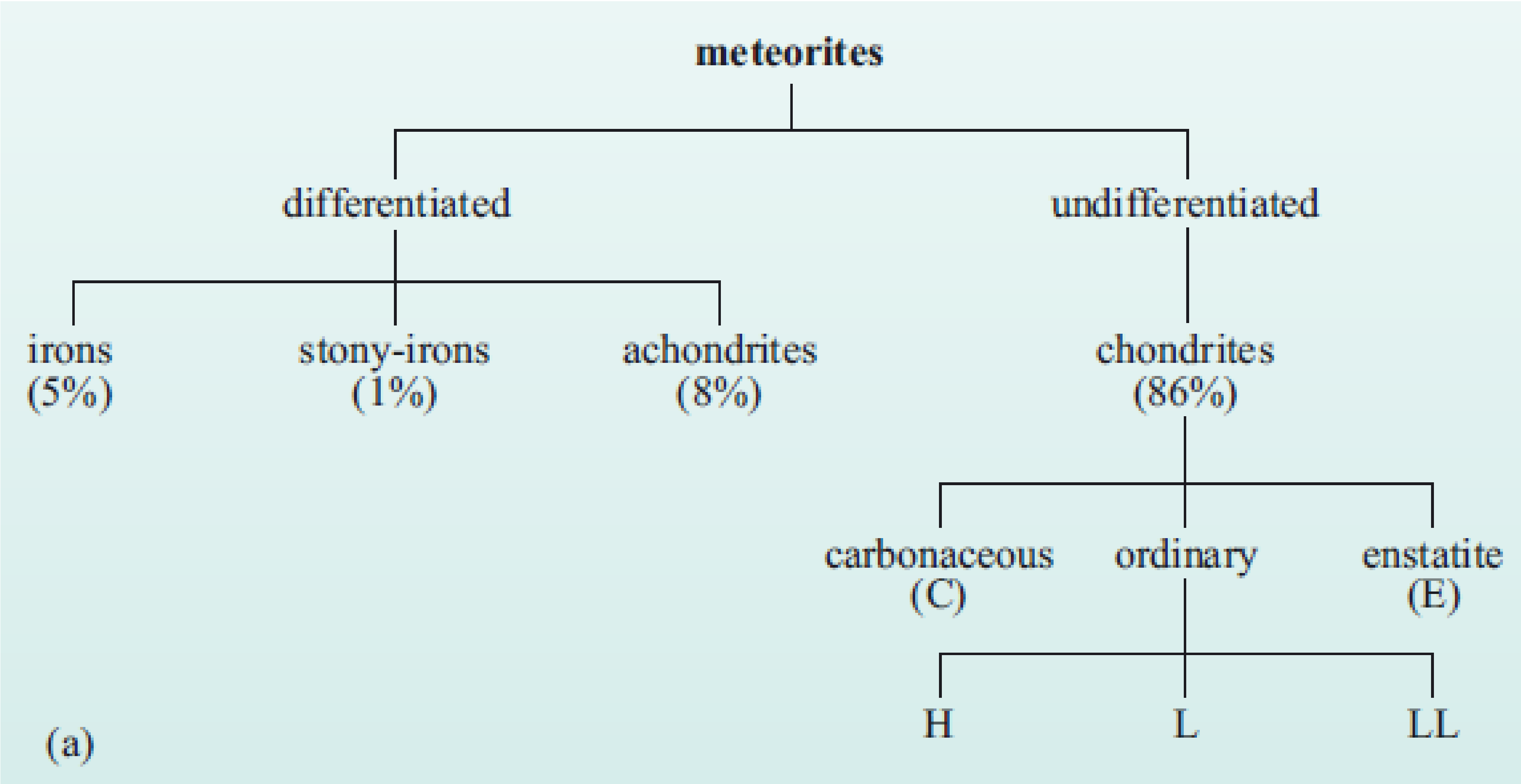
matrix; (e) a relatively large mm-sized chondrule from a carbonaceous chondrite (Bokkeveld meteorite), showing individual crystals within it; (f) a collection of individual chondrules, each less than 1 mm in diameter, from an ordinary chondrite (Sharps meteorite). (Natural History Museum)

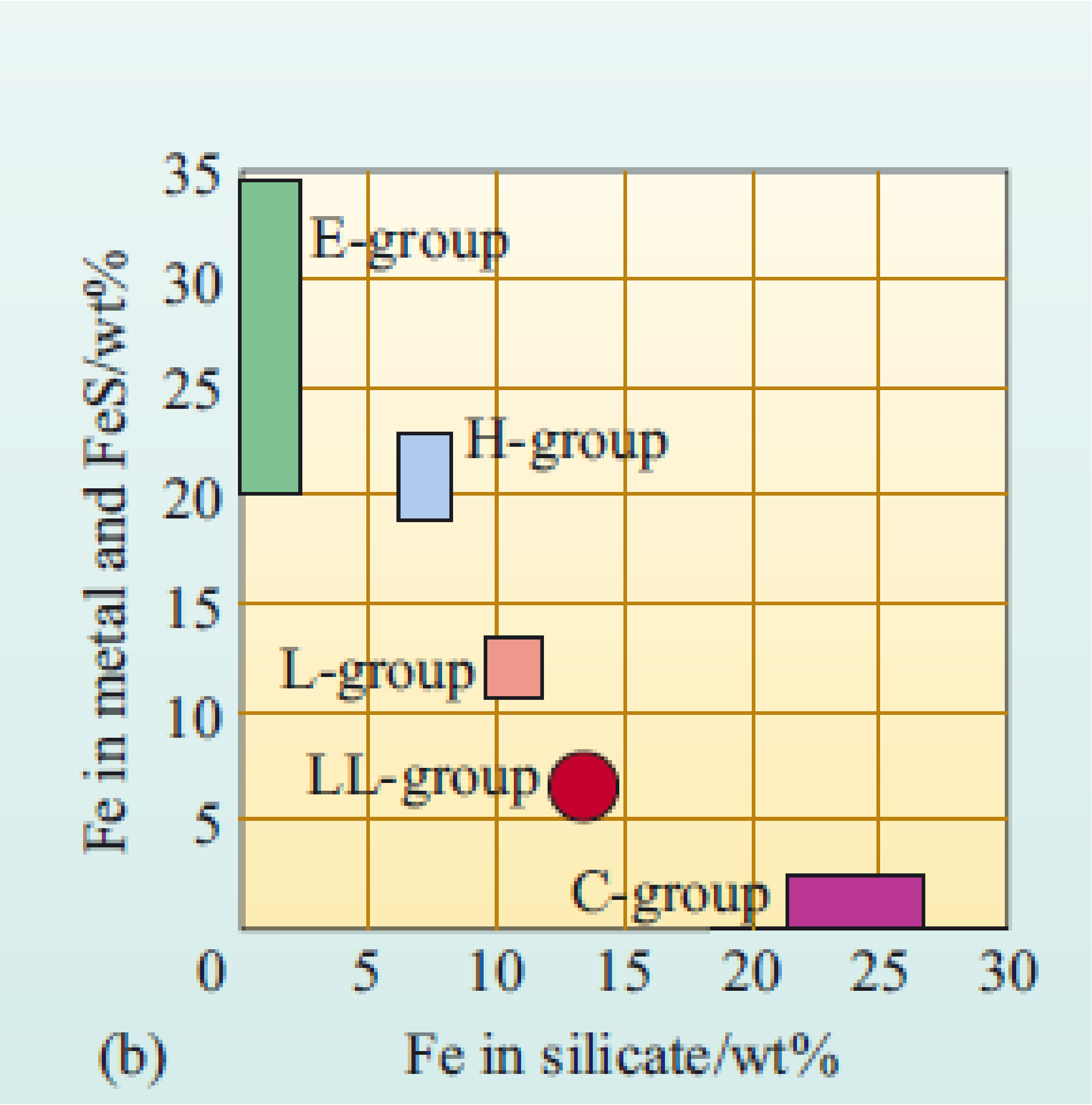
Achondrites- constitute only about 10% of all stony meteorite falls. Their textures suggest reminiscent of terrestrial Igneous rocks and are classified as differentiated meteorites along with iron and stony-irons.

Chondrites- are classified based on their mineralogy-

1. **Ordinary chondrites-** most abundant type
2. **Enstatite (or E-) chondrites-** rich in Enstatite ($MgSiO_3$)
3. **Carbonaceous (or C-) chondrites-** non biogenic carbon rich organic compounds in addition to silicates minerals.

Again ordinary chondrites are subdivided according to their iron Contents and their oxidation state (reflected in the amount of iron In silicate minerals) relative to that in chemically reduced phases Such as metallic iron and sulfides.


meteorites
differentiated
undifferentiated
irons
(5%)
stony-irons
(1%)
achondrites
(8%)
chondrites
(86%)
carbonaceous
(C)
ordinary
enstatite
(E)
H
L
LL
(a)



35
30
25
20
15
10
5
0
5
10
15
20
25
30
E-group
H-group
L-group
LL-group
C-group
Fe in metal and FeS/wt%
Fe in silicate/wt%
(b)

Considering this overall classification, what do you consider to be the dominant process in meteorite differentiation?

The separation of a metallic phase from the silicate minerals.