Meteorite Classification Table

Increasing Temperature

Stones (93.8% of Falls)

Chondrites (85.8%)

Increasing Oxidation State — Inner Solar System

- **Enstatite Chondrites (1.5%)** — Extremely reduced mineralogy; Ca, Na, Mg & Cr-bearing sulfides, enstatite-dominated.
  - **EH3-6 Chondrites** — More metal & sulfide. Niningerite - (Mg,Fe,Mn)S diagnostic. 56-63 vol.% enstatite. >3% Si in kamacite.
  - **EL3-6 Chondrites** — Less metal & sulfide. Alabandite - (Mn,Fe)S diagnostic. <3% Si in kamacite, 64-66 vol.% enstatite.
- **G3 Chondrites** — New group (published). Reduced ($Fa_{0.3-1.3}$), metal-rich (23%), no matrix or CAIs. Large chondrules, brecciated.
- **K3-4 Chondrites** — 6-9% metal. 70-77% matrix. Fs_4, Fa_2. Probable inner solar system (because very reduced).
- **Ordinary Chondrites (76.2%)**
  - **HH Chondrites** — Possible group. Slightly more reduced than H (~Fa_{14}). Metal rich. Maybe clasts in IIE.
  - **H3-6 Chondrites (31.3%)** — Mainly Opx & Olivine (Fa_{16-20}), minor Plag, Fe-Ni = 15-19%, + FeS.
  - **L3-6 Chondrites (35.6%)** — Mainly Opx & Olivine (Fa_{21-25}), minor Plag, Fe-Ni = 4-10%, + FeS.
  - **LL3-6 Chondrites (8%)** — Mainly Opx & Olivine (Fa_{26-32}), minor Plag, Fe-Ni = 0.3-3%, + FeS. Larger Chondrules.
- **R3-6 Chondrites** — 50% matrix. Ni-bearing olivine (Fa_{37-40}). No metal. No CAIs. Most are metamorphosed & brecciated.

Unknown

- **F3-6 chondrites** — Not a recognised group yet. Metal rich matrix (30%), reduced (Fa_{4-6}). O isotopes separate to K chondrites and winonaites.

Increasing Oxidation State — Outer Solar System

- **Carbonaceous Chondrites (3.6%)**
  - **CB Chondrites** — 60-75% metal (as large chondrules). Non-porphyritic Mg-rich (Fa_4, Fs_4) metal-free chondrules. Rare CAIs. No matrix. Hydrated clasts.
  - **CR1-2 Chondrites** — ~35-45% small (~300mm) chondrules. ~10% CAIs & AOAs. Abund metal-rich chonrules. Anhydrous Alt chondrules.
  - **CH3 Chondrites** — ~20% indiv. metal grains. Small 20-90mm chondrules & CAIs. Mainly CC chondrules. Minimal matrix, hydrated clasts.
  - **CL3.9-4 Chondrites** — Similar metal to CR. Similar chondrules to CV, but 1.8% CAIs. Lowest matrix, except CH. Nearly equil. Ol ($Fa_{12.5-14.7}$). Depleted Volatiles.
  - **CO3-3.7 Chondrites** — Abund large metal-rich Mg chondrules. Minor CAIs & AOAs. Heavily hydrated matrix & matrix-like lithic clasts.
  - **CV3 Chondrites** — Abund CAIs & AOAs, 40% matrix 0.5-1.2mm chondrules. CV_{red}: metal, no phyllosilicates; CV_{oxa}, CV_{oxb}: magnetite, phyllosilicates
  - **CK3-6 Chondrites** — Abund matrix. 0.7-1mm porphyryitic chondrules. No metal. Abund. magnetite, Ni-rich sulfide. Rare CAIs & AOAs.
  - **CY1-2 Chondrites** — Sparse chondrules, little/no metal. Phyllosil. & magnetite in in matrix. Abundant sulfides & phosphates. $\delta^{17}O$ ~12‰ & $\delta^{18}O$ ~22‰.
  - **CM1-2 Chondrites** — ~30% small (<0.3mm) chondrules, part repl. by phyllosilicates. No metal. Common CAIs and AOAs. 70% matrix.
  - **CI1 Chondrites** — No chondrules or metal. Phyllosilicates, olivine & magnetite in black matrix. Up to 20% H_2O. Solar abundance of elements.

Achondrites (8%)

relative fO_2

- **Primitive (1.7%)**
  - **Ungr. Prim. Ens. Achons.**
  - **Winonaites** — Fine-med.grained Opx-rich, mod Ol ($Fa_{1-5;\ FeO/MnO = 2-27}$), minor Cpx, Plag. Fe-FeS veins. Clasts in IAB.
  - **Tissemouminites** — Transitional chon-achon (>Type 5, chondrules). Ol ($Fa_{6-6.5,\ FeO/MnO = 10-14}$), K-rich plag, metal rich.
  - **Acapulcoites** — Fine-grained (150-230μm) Ol (Fa_{7-14}), Opx, Cr-diop, Na-Plag, metal, troilite. Relict chondrules.
  - **Lodranites** — Coarse-grained (>540μm) Ol (Fa_{7-14}), Opx, Cr-diop, metal. May be plag, metal & troilite depleted.
  - **Ureilites** — Graphite/diamond-rich coarse Ol-Pig or Ol-Pig-Opx residues of melt loss. Ol (Fa_{5-24}) has smelted rims. No plag, metal depl
  - **Brachinites** — Primitive wehrlitic peridotites (Fa_{27-36}); 74-98% Ol, 4-15% Aug, variable Opx and Plag (melt loss), 3-7% sulf.
  - **Ungrouped** — NWA 7822 (Fa_{28}), 10503 (Fa_{32})
  - **Ténéréites** — Oxised (~Fa_{29-38}), grouped on O, Cr, Ti isotopes. Tafassasset, NWA 3100, 5131, 7317 (type 6), 12455
    Not an official group
- **Evolved (6.3%)**
  - **Aubrites** — Enstatite pyroxenites. Mostly regolith breccias. 75-90% Enst. + albitic plag, FeO-free diop, forsterite. Ac. Metal
  - **Lunar** — Unbx mare basalts, mare basalt bx, mixed mare/highland bx, highland regolith bx & highland melt bx.
  - **Martian**
    - **Shergottites** — Basaltic (mafic); Gabbroic (mafic); Olivine phyric (permafic); Poikilitic (ultramafic)
    - **Nakhlites** — Cumulate augite-rich clinopyroxenites, minor Ol.
    - **Orthopyroxenite** — ALH 84001. Cumulate 96% Opx, 2% chromite, 1% Plag.
    - **Chassignites** — Olivine-chromite cummulates.
    - **Basaltic breccia** — Heterogeneous regolith breccias
  - **Vestoids (incl.HED group)**
    - **Howardites** — Polymict breccias of eucritic & diogenitic material. Also impact melt clasts, C chondrite xenoliths.
    - **Eucrites** — Px-plag basalts. Noncumulate (surface basalt flows), cumulate (gabbros) & polymict varieties (breccias).
    - **Diogenites** — Coarse-grained cumulate orthopyroxenites. Minor Ol, Cpx, Chromite, Plag, Metal.
  - **Angrites** — Med-coarse-grained (<3mm) basalts. Ca-Al-Ti-rich Px, Ca-rich Ol, anorthite. Minor Metal. Highly Alkali depleted.
  - **Ungrouped** — Ibitira, GRA 06128, NWA 5400, 7325, 8054
  - **Andesitic Ungrouped** — Several unpaired examples known. Crystallised from evolved melt.
  - **Evolved Ténéréites** — Isotopically linked to the Ténéréites NWA 011/2976, 6704/6693 (Fa_{52}), 6962(Fa_{47})
    Not an official group

Clasts in IIE: H7, L7, LL7, R7, EH7, EL7, CV7

NWA 2653, 3133 Fa_{22}, metal

Stony-Irons (1.2%)

- **Pallasites**
  - **Main Group** — Approx. equal olivine (Fo = 82-88 mol.%) & metal (minor troilite).
  - **Pyroxene** — 14–63 vol.% olivine, 30–43 vol.% metal, 0.7–3 vol.% pyroxene, 0–1 vol.% troilite.
  - **Eagle Station** — More Fe- & Ca-rich olivine than MG pallasites. Metal has higher Ni & Ir than MG pallasites.
- **Mesosiderites** — Polymict igneous breccias. Subclasses: A basaltic, B ultramafic, C orthopyroxenite. Texture grades 1 (cataclastic) to 4 (igneous). Metal nodules.

Irons (5%)

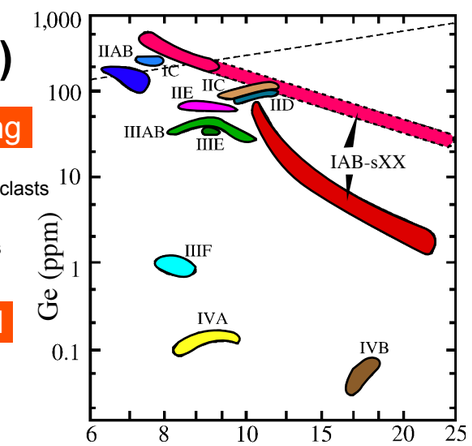
Silicate-bearing

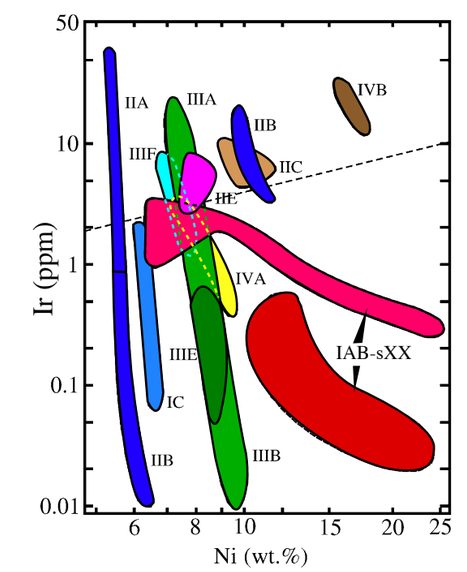
Inner SS
- **IAB-sXX** — Win. clasts
- **IIE** — H chon clasts

Fractionated

Inner SS
- IC
- IIAB
- IIIAB
- IIIE
- IVA

Outer SS
- IIC
- IID
- IIF
- IIIF
- IVB





A.G. Tomkins, 2022 (with thanks to D. Weir and M. Ouzillou for suggestions)