Some definitions about primitive meteriote:

[Primitive meteorites - (Intro to Astronomy) - Vocab, Definition, Explanations | Fiveable](https://library.fiveable.me/key-terms/intro-astronomy/primitive-meteorites)

1. Primitive meteorites are also known as chondrites due to the presence of chondrules, which are round grains formed from molten droplets.
2. They contain a mixture of metal and silicate minerals, with some also containing organic compounds and presolar grains.
3. Primitive meteorites are thought to originate from undifferentiated asteroids that never melted and separated into different layers.
4. They provide crucial information about the conditions and processes in the early solar system, including the composition of the primordial solar nebula.
5. Some primitive meteorites contain tiny inclusions called calcium-aluminum-rich inclusions (CAIs), which are among the first solids to condense from the solar nebula.

An article about primitive meteorites：

IEEE citation: J. Aléon, “Meteorites and the physico-chemical conditions in the early solar nebula,” *arXiv preprint arXiv:0809.1735*, Sep. 2008. [Online]. Available:<https://arxiv.org/pdf/0809.1735>.

Overview：

This paper investigates the mineralogical, chemical, and isotopic properties of meteorites to understand the physical and chemical conditions in the early solar nebula, which played a pivotal role in the formation and evolution of the solar system.

**1. Meteorite Classification and Characteristics**

**Chondrites**

* **Definition**: The most primitive type of meteorite, unaltered by melting.
* **Components**:
  + **Chondrules**: Spherical silicate grains formed by rapid cooling from molten droplets.
  + **Calcium-Aluminum-Rich Inclusions (CAIs)**: Among the first solids to condense in the solar nebula, providing clues about high-temperature processes.
  + **Matrix**: Fine-grained material that reflects the solar nebula's bulk composition.
* **Significance**: Chondrites retain the chemical and isotopic information of the early solar nebula, making them key to studying pre-planetary processes.

**Achondrites**

* **Definition**: Meteorites that have undergone partial melting and differentiation.
* **Components**:
  + Lack of chondrules.
  + Evidence of parent-body processing (e.g., core formation, crustal evolution).
* **Significance**: Provide insights into planetary differentiation and thermal evolution.

**2. Physical and Chemical Conditions in the Early Solar Nebula**

**Chemical Composition**

* Dominated by hydrogen and helium, with trace amounts of heavier elements and dust grains.
* Dust grains served as building blocks for CAIs, chondrules, and later, planetesimals.

**Temperature and Pressure Gradients**

* The solar nebula exhibited a steep temperature gradient, influencing the condensation sequence of elements:
  + High-temperature regions closer to the Sun formed refractory materials like CAIs.
  + Cooler outer regions allowed volatile elements and ices to condense.

**Dynamical Processes**

* **Turbulence and Radial Transport**: Contributed to the mixing and redistribution of material, forming distinct chemical and isotopic reservoirs.
* **Gas-Solid Interactions**: Governed the aggregation of dust grains into larger particles and eventually planetesimals.

**3. Isotopic Signatures and Implications**

**Oxygen Isotopes**

* Meteorites exhibit anomalies in oxygen isotopic composition, indicative of isotopic heterogeneity in the solar nebula.
* These variations provide constraints on the mixing and processing of material in the nebula.

**Short-Lived Radionuclides (e.g., 26^{26}26Al and 60^{60}60Fe)**

* The presence of radioactive isotopes in meteorites suggests the solar system formed shortly after a nearby supernova or stellar wind injected these isotopes into the nebula.
* 26^{26}26Al decay provides precise dating for early solar system processes.

**4. Chondrules and CAIs**

* **Chondrules**:
  + Likely formed in transient heating events (e.g., shock waves or nebular lightning) at temperatures of 1500–2000 K.
  + Their formation timescales help constrain the duration of solar nebula activity.
* **CAIs**:
  + The oldest known solids in the solar system (dated to ~4.567 billion years ago).
  + Represent the earliest high-temperature condensates from the solar nebula.