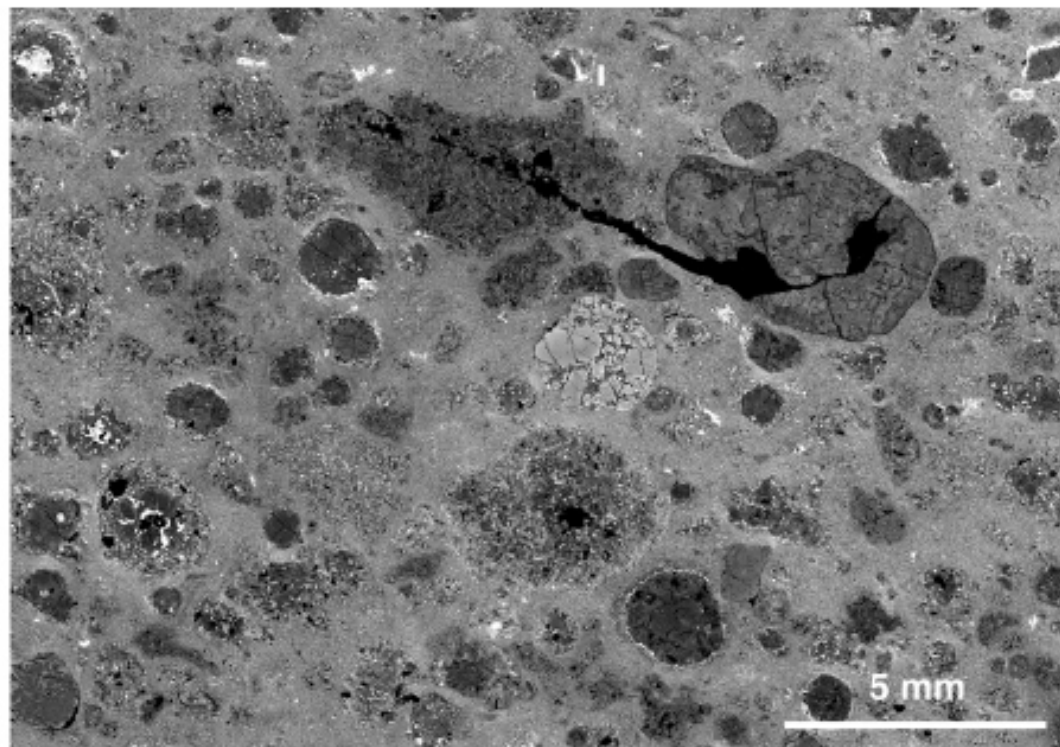


始源的隕石 (chondrites)

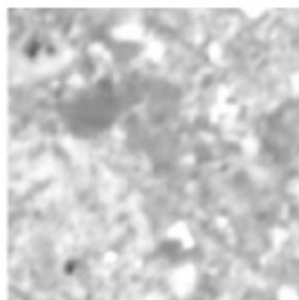
Refractory inclusions
(CAIs, AOAs)
Chondrules
Matrix



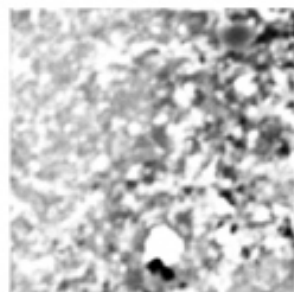
Chondriteの反射電子像



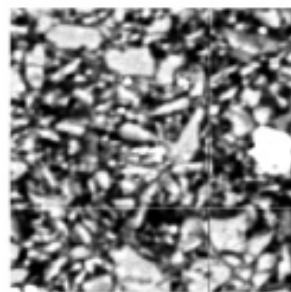
Matrix



Murchison CM2



Y81020 CO3

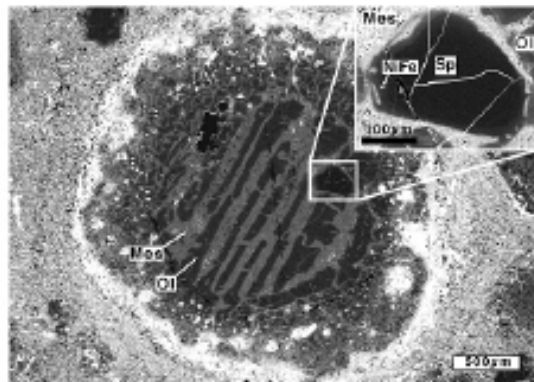


Allende CV3

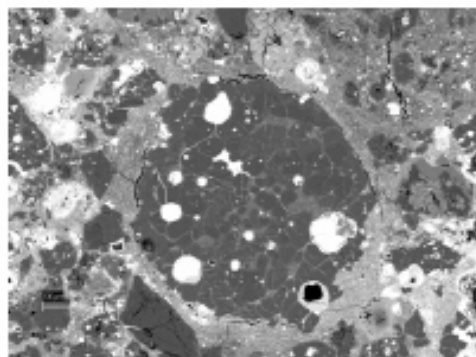
Width: 20µm

- 主要成分
 - ケイ酸塩
 - 無水、含水
 - 金属鉄
 - 硫化鉄
- 副成分
 - グラファイト
 - 有機物
 - 酸化物
 - プレソーラ粒子
 - New-PCP

Chondrule



Allende

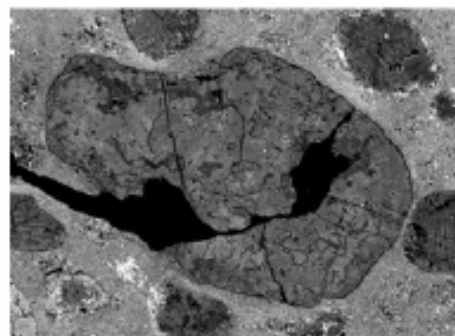


Y81020

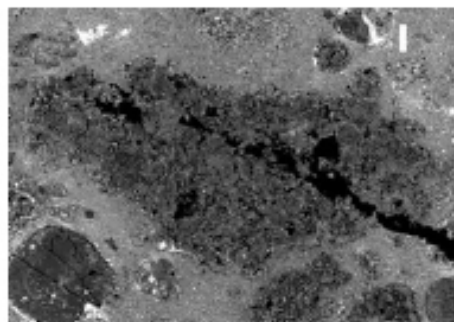
- 球状の液滴固結物
 - 晶出鉱物
 - メソスタシス
 - ガラス, 微細結晶
- 0.1-1(5)mmサイズ 分布

- 成分
 - ケイ酸塩
 - 金属鉄
 - 硫化鉄

Refractory inclusions



Allende

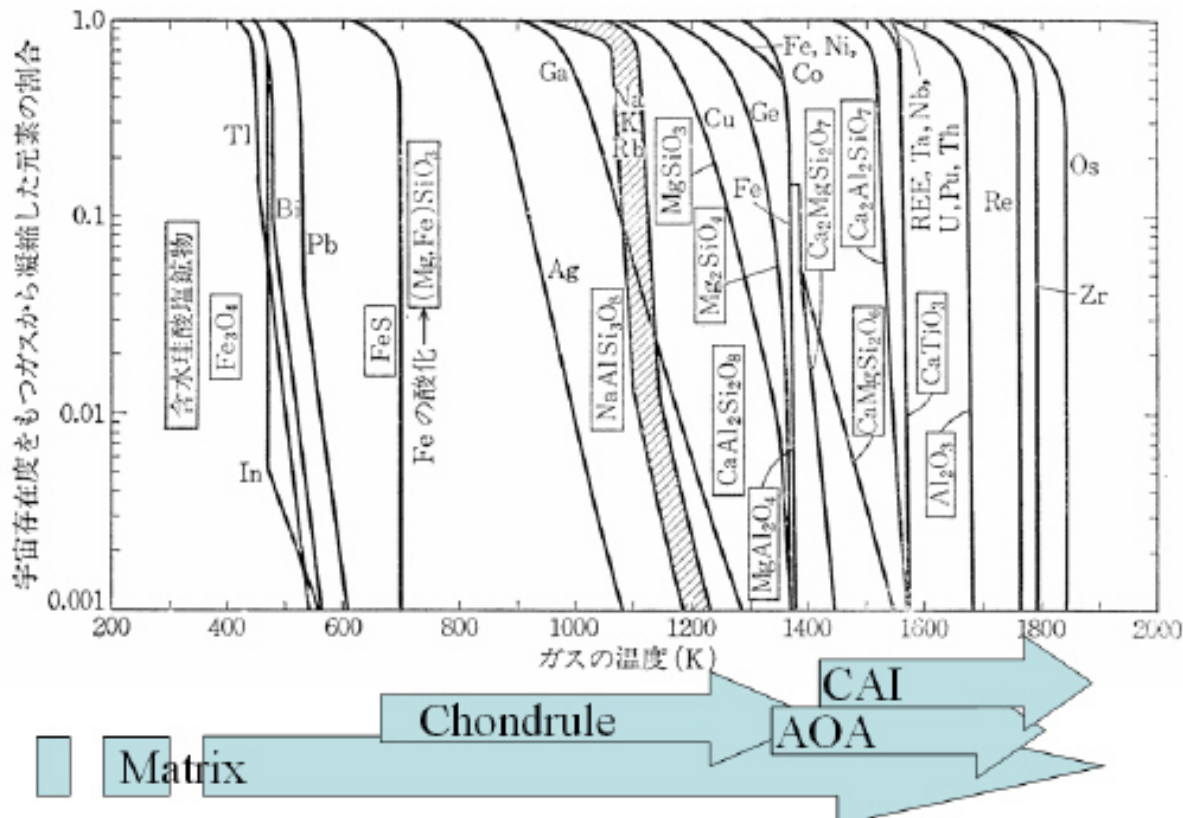


Allende

横幅7mm

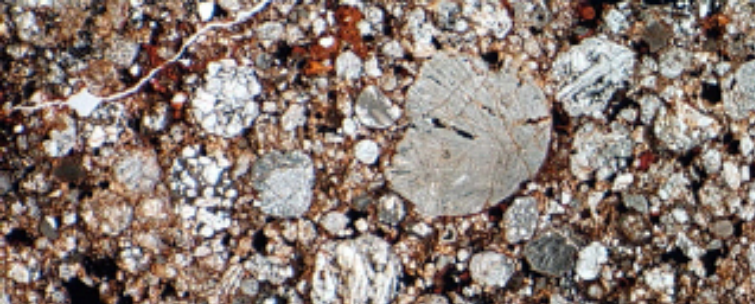
- **Ca-Al-rich inclusion (CAI)**
 - 10 μ m-2cm
 - 固相凝縮, 液滴固結
 - 酸化物
 - ケイ酸塩
 - 金属粒子
 - 硫化物
- **Amoeboid olivine aggregate (AOA)**
 - 10 μ m-1cm
 - 固相凝縮
 - Olivine
 - Ca-Alケイ酸塩
 - 金属粒子
 - 硫化物

太陽系存在度における鉱物晶出温度

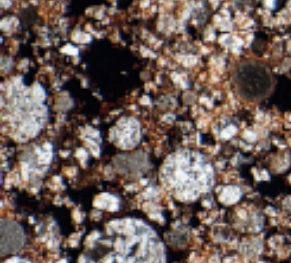


Chondrite classification

- Ordinary
 - H
 - L
 - LL
- Enstatite
 - EH
 - EL
- Kakangari-type
- Rumurutiite
- Carbonaceous
 - CI
 - CM
 - CR
 - CO
 - CV
 - CK
 - CH



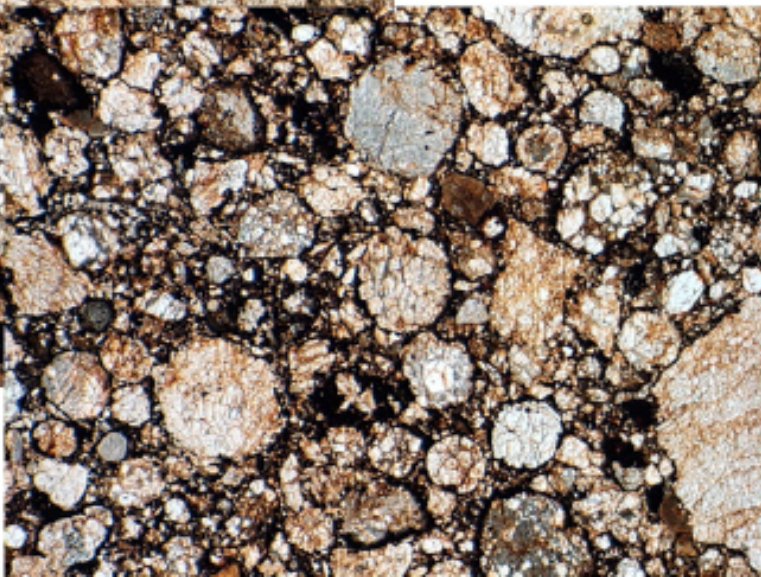
O chondrites



H

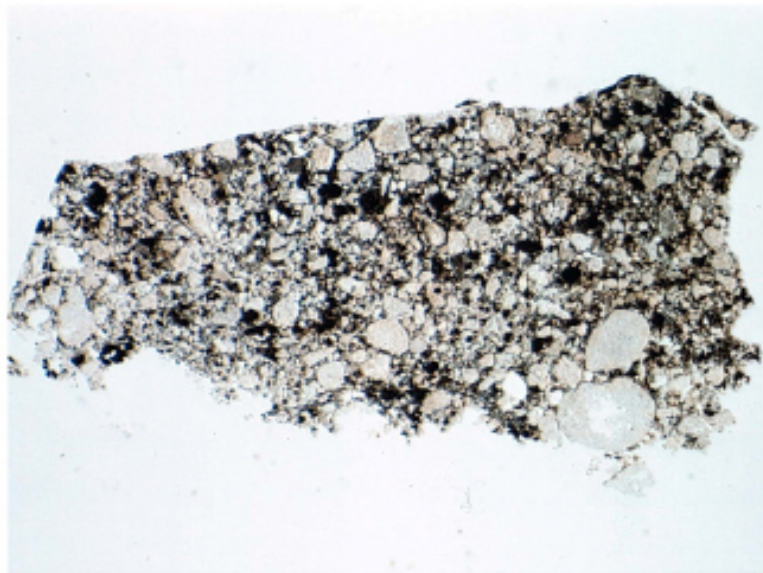


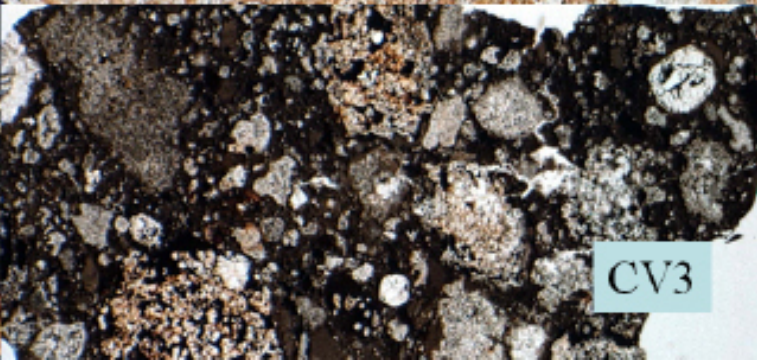
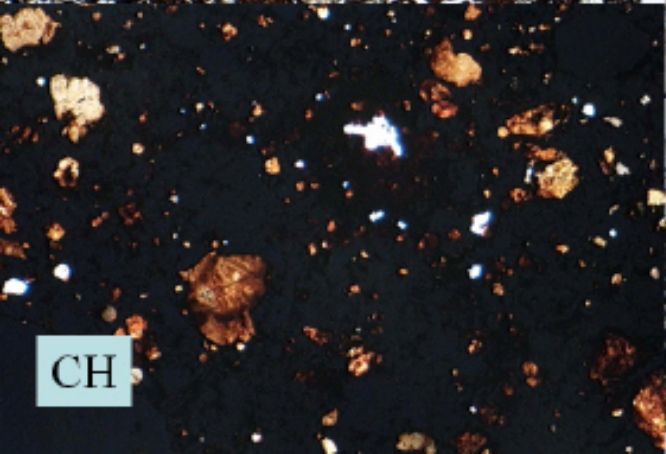
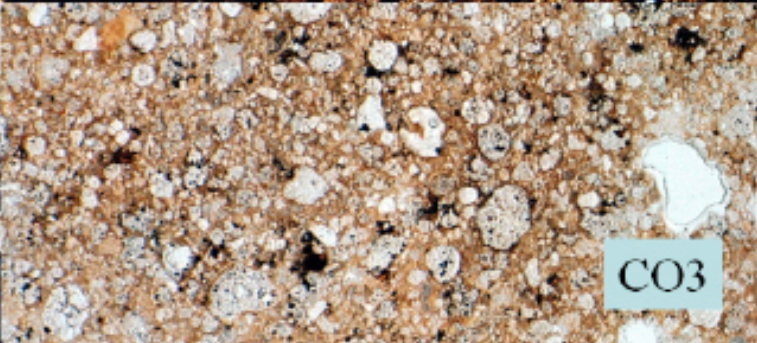
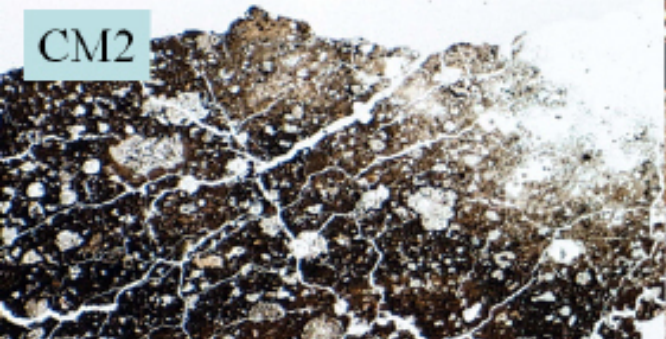
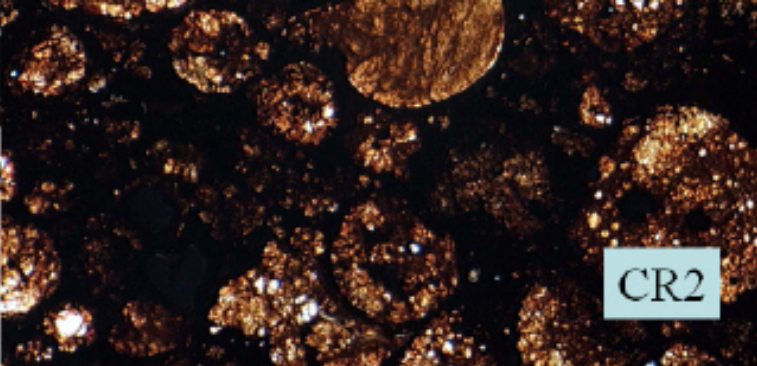
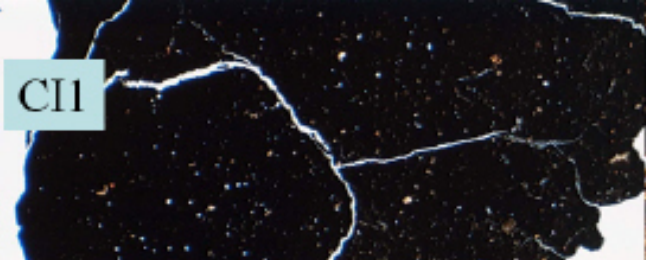
L



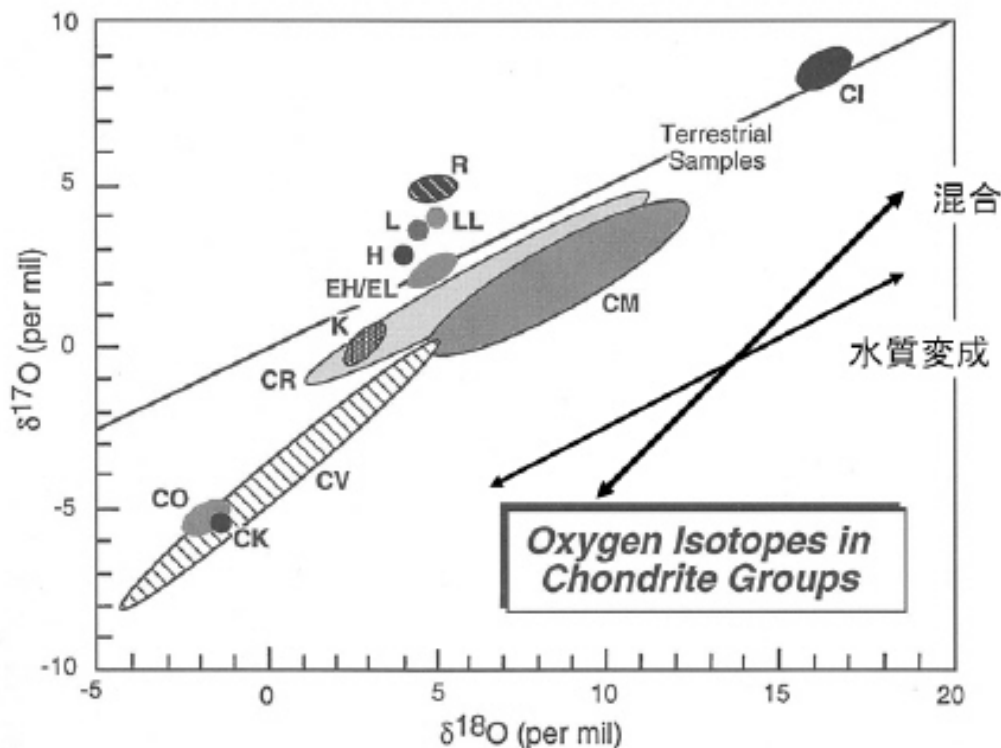
LL

E chondrites





How many parent bodies?



Petrologic Types

Thermal Metamorphism

<400K

~1200K

3

4

5

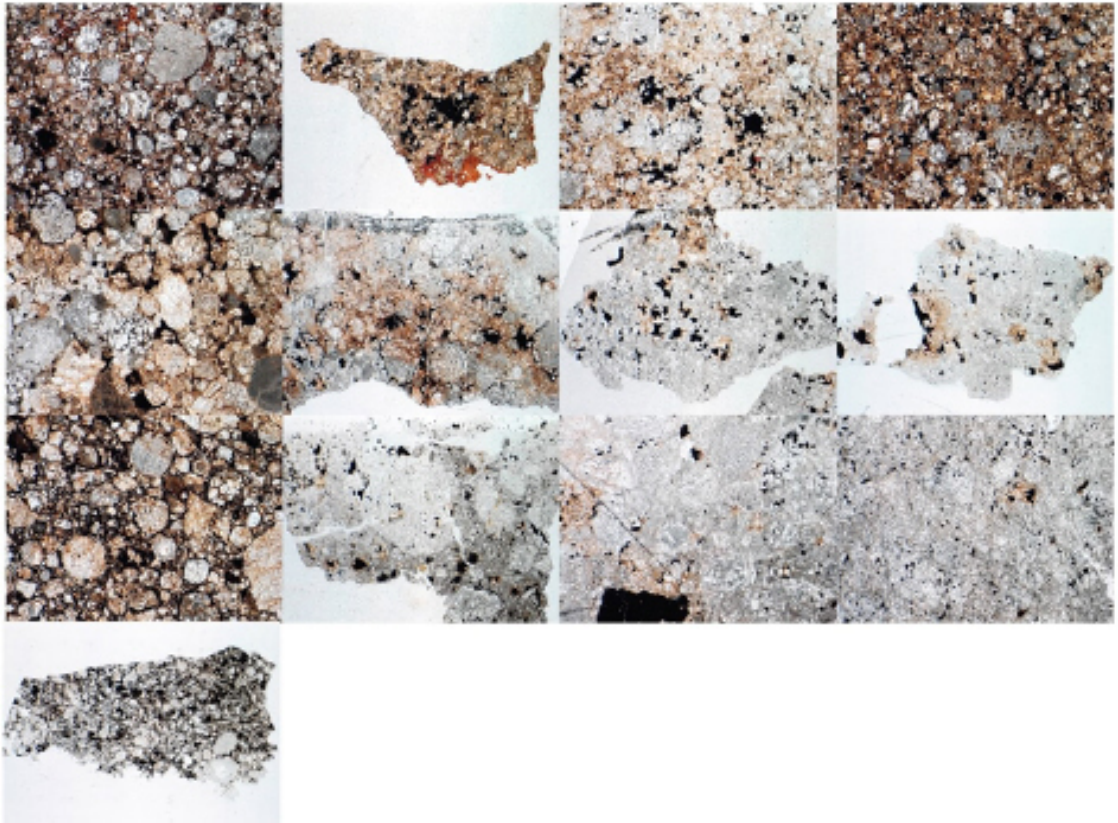
6

H

L

LL

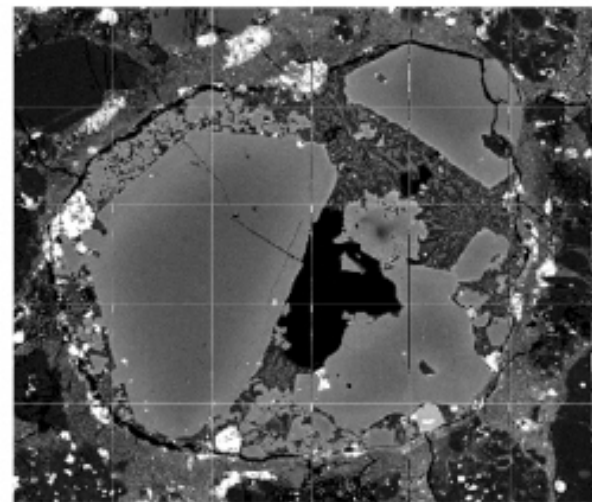
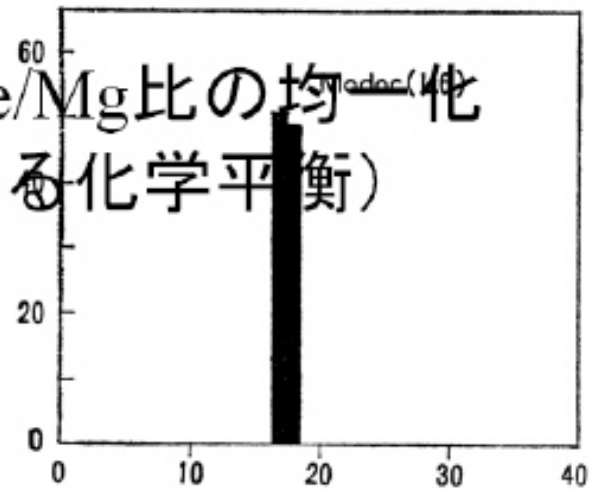
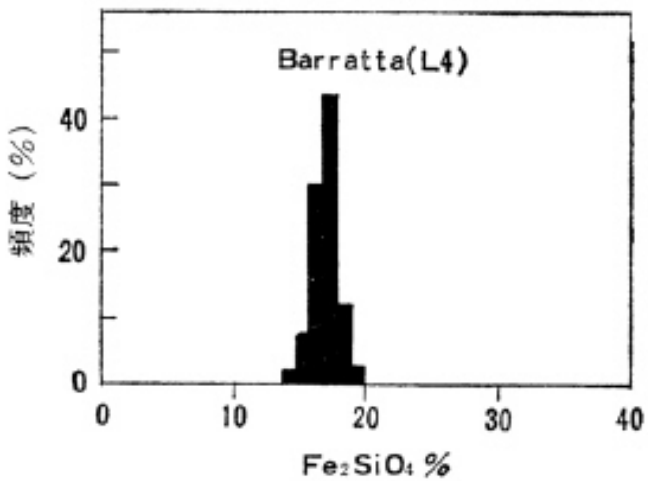
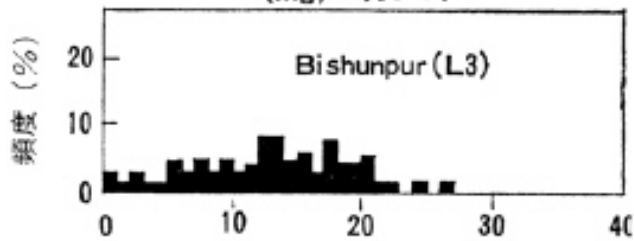
E



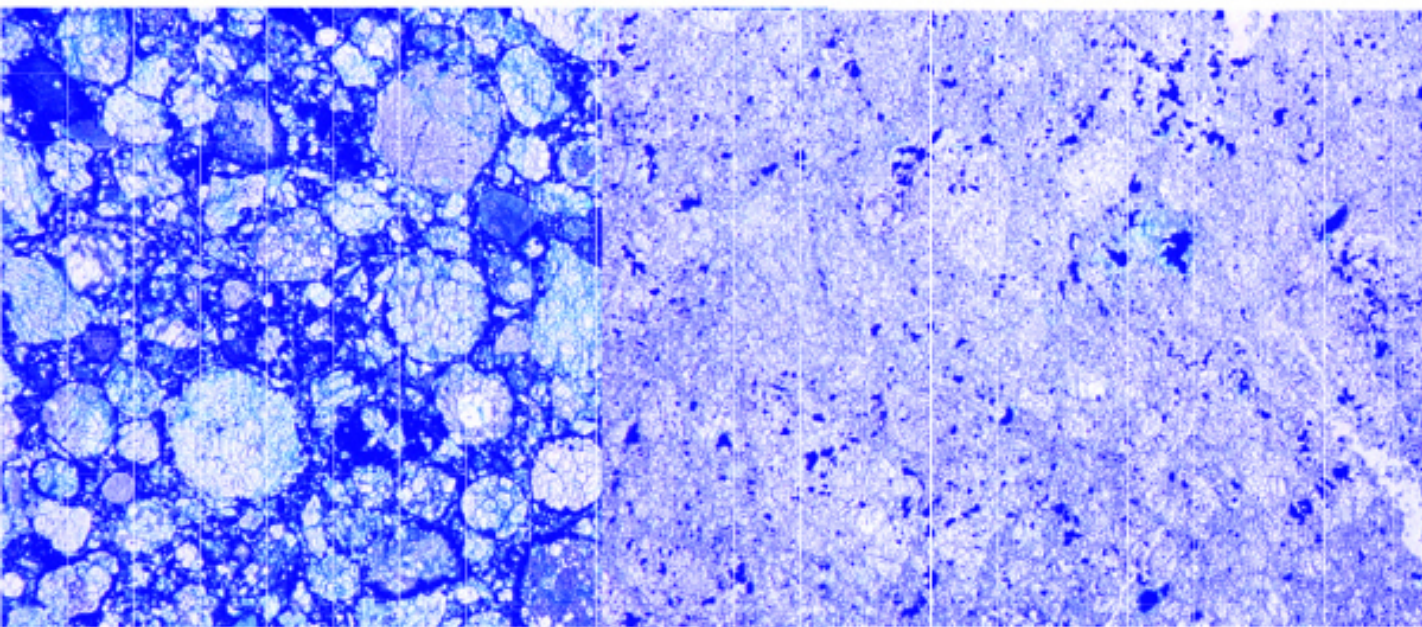
変成作用によるFe/Mg比の均一化 (元素拡散による化学平衡)

カンラン石
(Mg,Fe)₂SiO₄

頻度 (%)



変成作用による粗粒化（元素拡散による組織平衡）



LL3

LL6

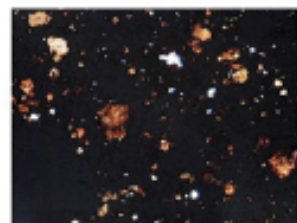
<300-450K

Aqueous Alteration

1

2

3

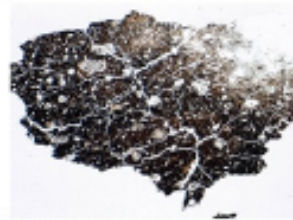


CH

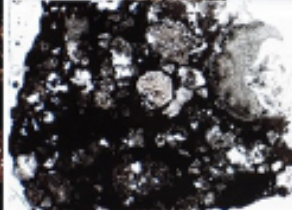
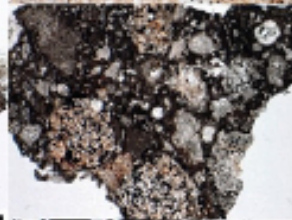
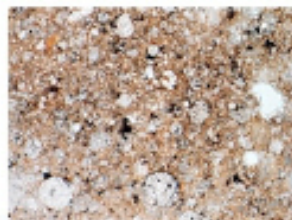
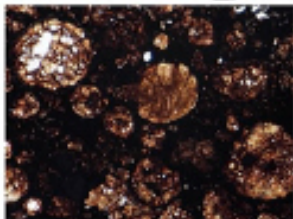
CI



CM



CR



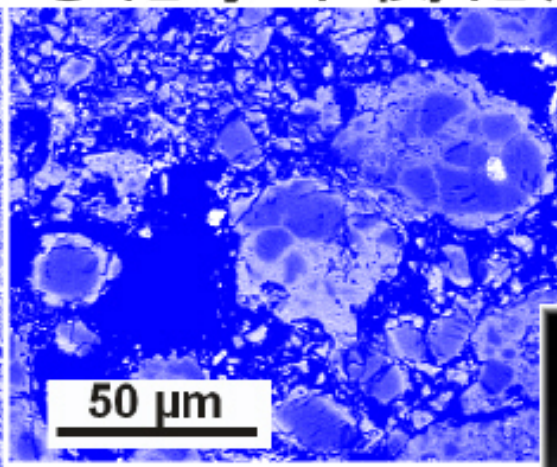
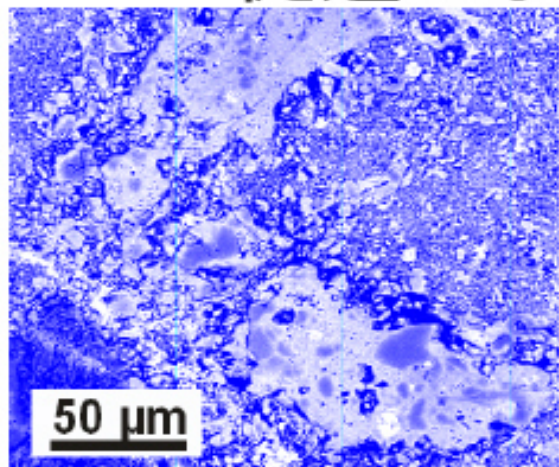
CO

CV

CK

粘土化による岩石組織の破壊

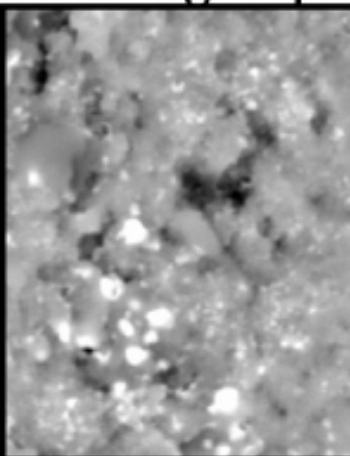
水質変成（水溶液による反応 促進による化学平衡化）



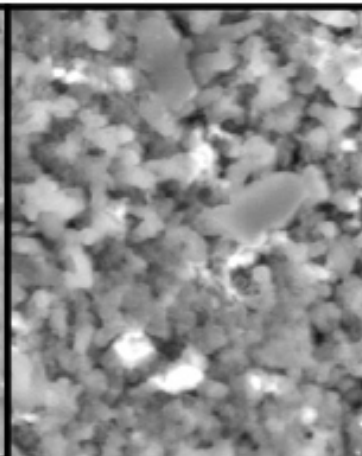
未變成未變質？



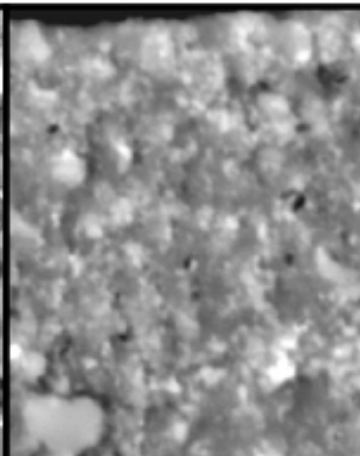
Acfer 094
C3-ungrouped



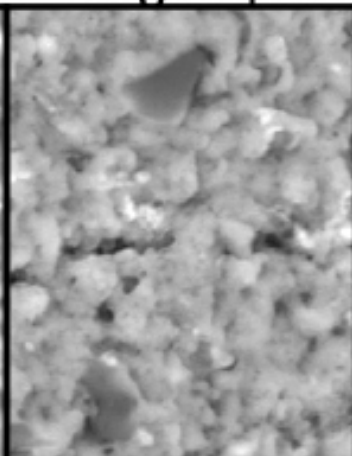
Y-81025
CO3.0



ALHA77307
CO3.0



Adelaide
C3-ungrouped



2 μ m

未變成未變質？

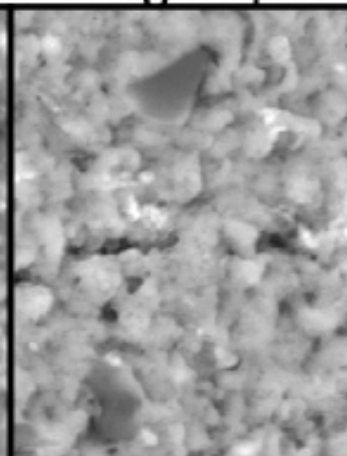
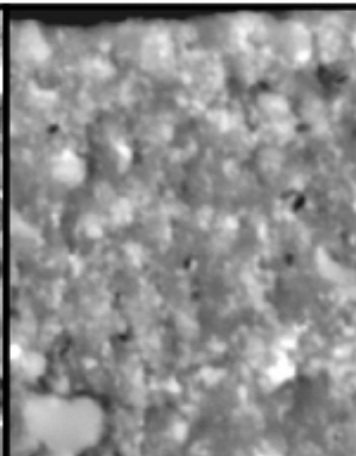
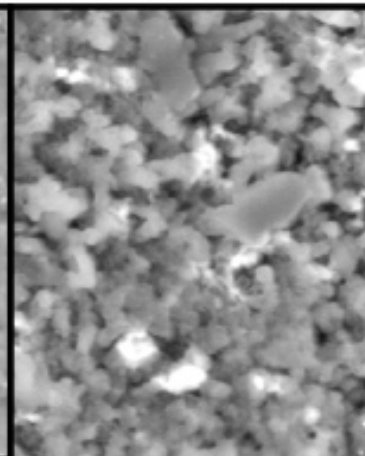
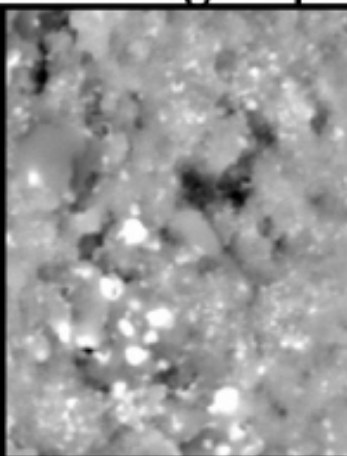


Acfer 094
C3-ungrouped

Y-81025
CO3.0

ALHA77307
CO3.0

Adelaide
C3-ungrouped



TEM studies (Brearley, 1991, 1993; Greshake, 1997, 2004)

2 μ m

未變成未變質？

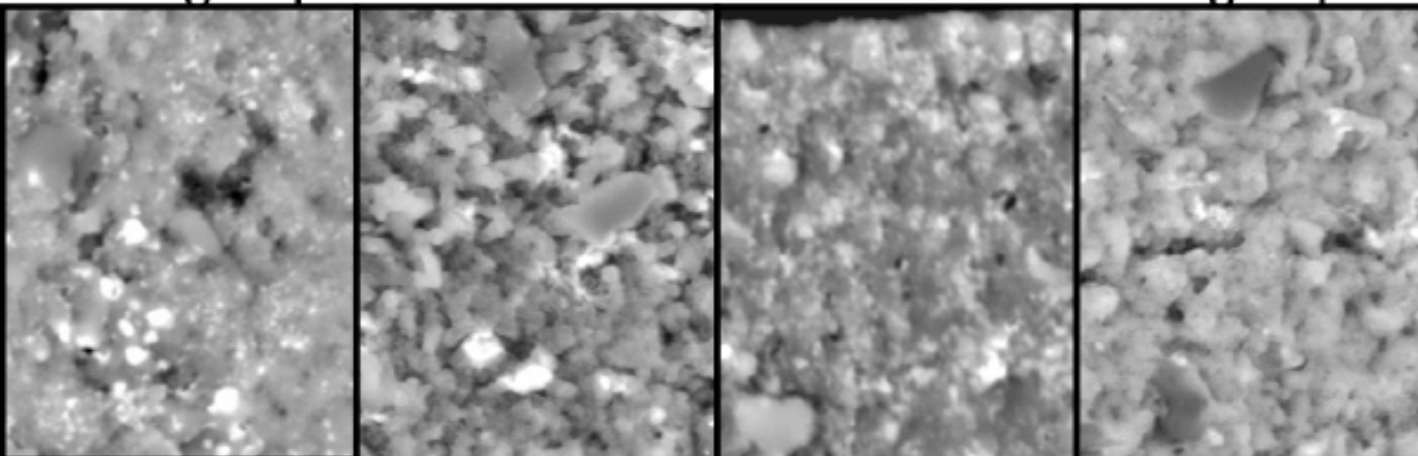


Acfer 094
C3-ungrouped

Y-81025
CO3.0

ALHA77307
CO3.0

Adelaide
C3-ungrouped



TEM studies (Brearley, 1991, 1993; Greshake, 1997, 2004)

Matrices contain Fe-rich amorphous silicates.

2 μ m

未變成未變質？

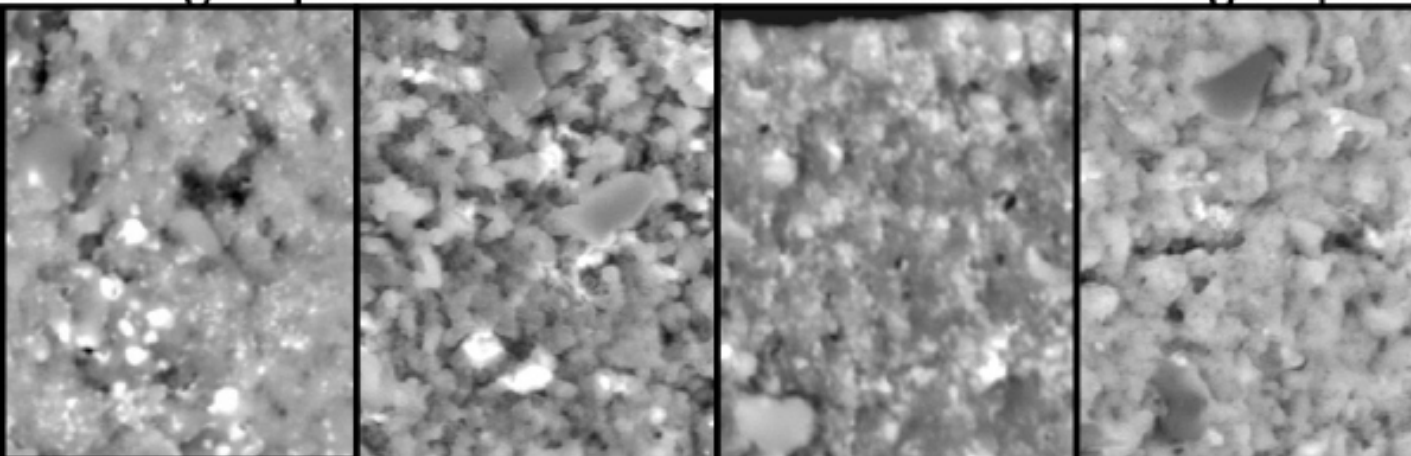


Acfer 094
C3-ungrouped

Y-81025
CO3.0

ALHA77307
CO3.0

Adelaide
C3-ungrouped



TEM studies (Brearley, 1991, 1993; Greshake, 1997, 2004)

Matrices contain Fe-rich amorphous silicates.

No hydrous phyllosilicate

2 μ m

未變成未變質？

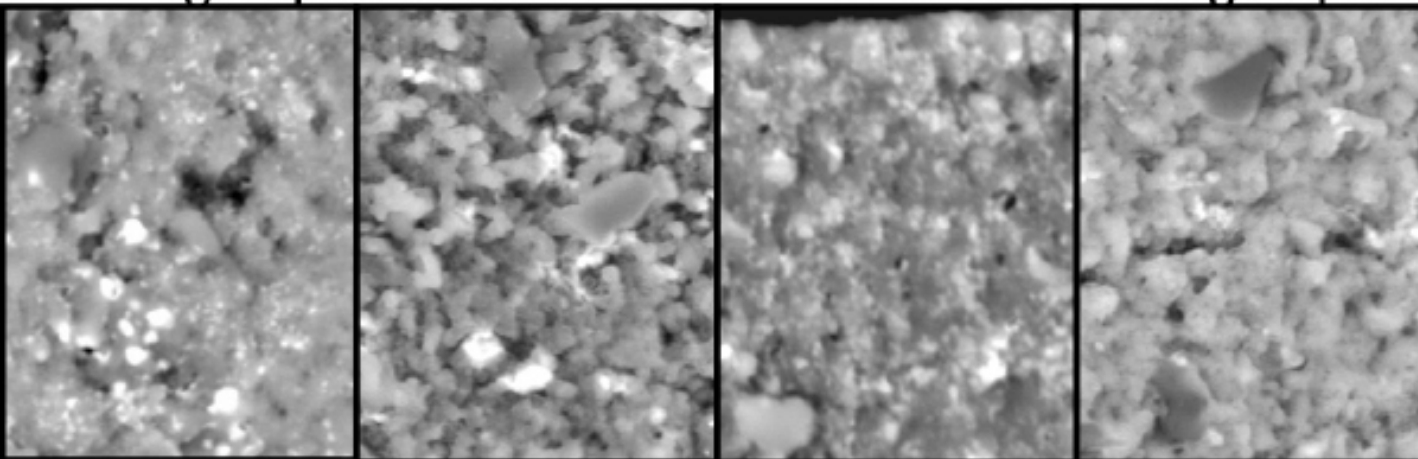


Acfer 094
C3-ungrouped

Y-81025
CO3.0

ALHA77307
CO3.0

Adelaide
C3-ungrouped



TEM studies (Brearley, 1991, 1993; Greshake, 1997, 2004)

2μm

Matrices contain Fe-rich amorphous silicates.

No hydrous phyllosilicate → No aqueous alteration

未變成未變質？

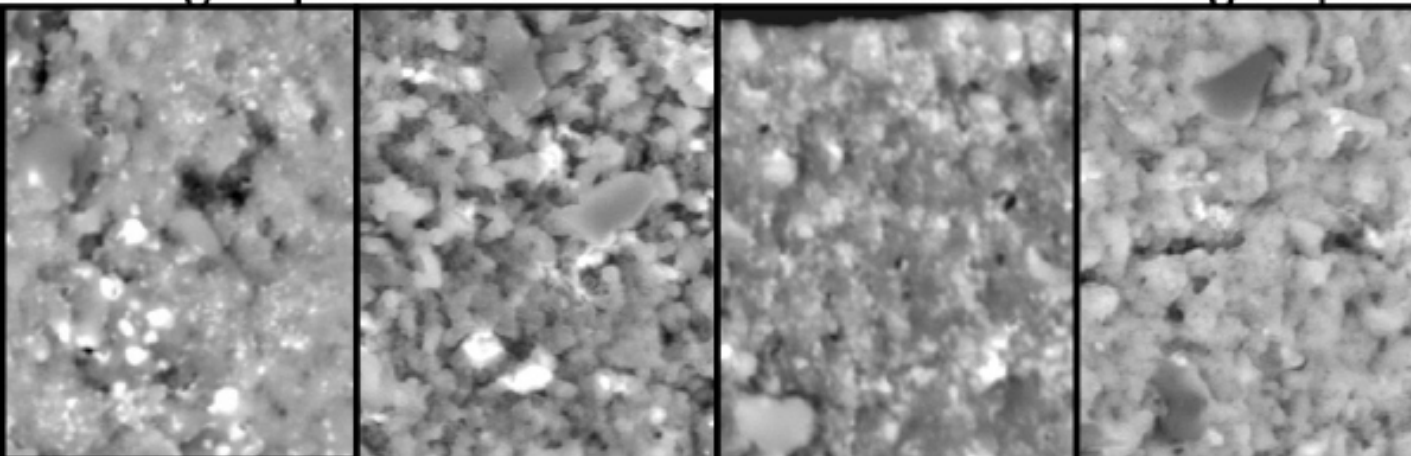


Acfer 094
C3-ungrouped

Y-81025
CO3.0

ALHA77307
CO3.0

Adelaide
C3-ungrouped



TEM studies (Brearley, 1991, 1993; Greshake, 1997, 2004)

2 μ m

Matrices contain Fe-rich amorphous silicates.

No hydrous phyllosilicate  **No aqueous alteration**

Olivine: Fe-poor  **Fe-rich**

未變成未變質？

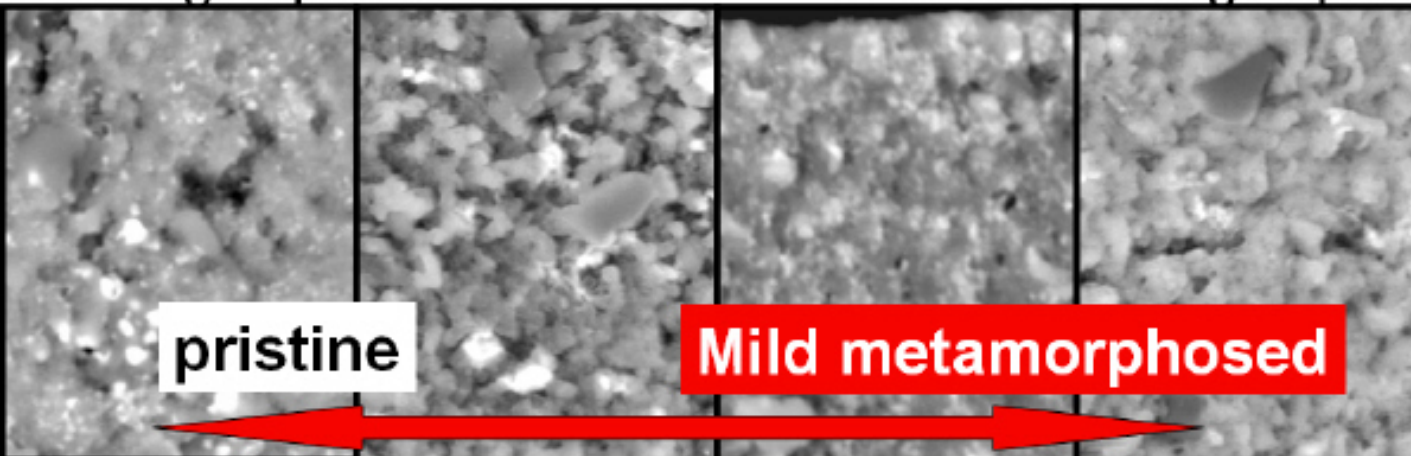


Acfer 094
C3-ungrouped

Y-81025
CO3.0

ALHA77307
CO3.0

Adelaide
C3-ungrouped



TEM studies (Brearley, 1991, 1993; Greshake, 1997, 2004)

2 μ m

Matrices contain **Fe-rich amorphous silicates**.

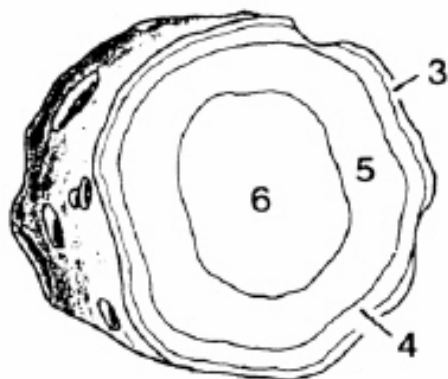
No hydrous phyllosilicate  No aqueous alteration

Olivine: Fe-poor  Fe-rich

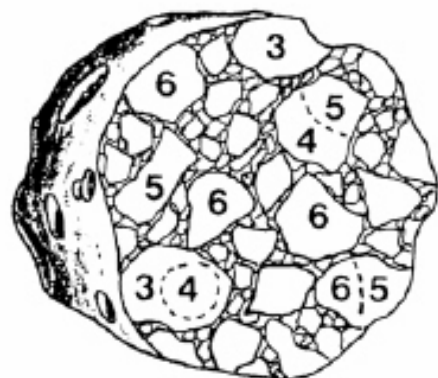
Chondrite母天体

数km~数10km

Asteroid Structures

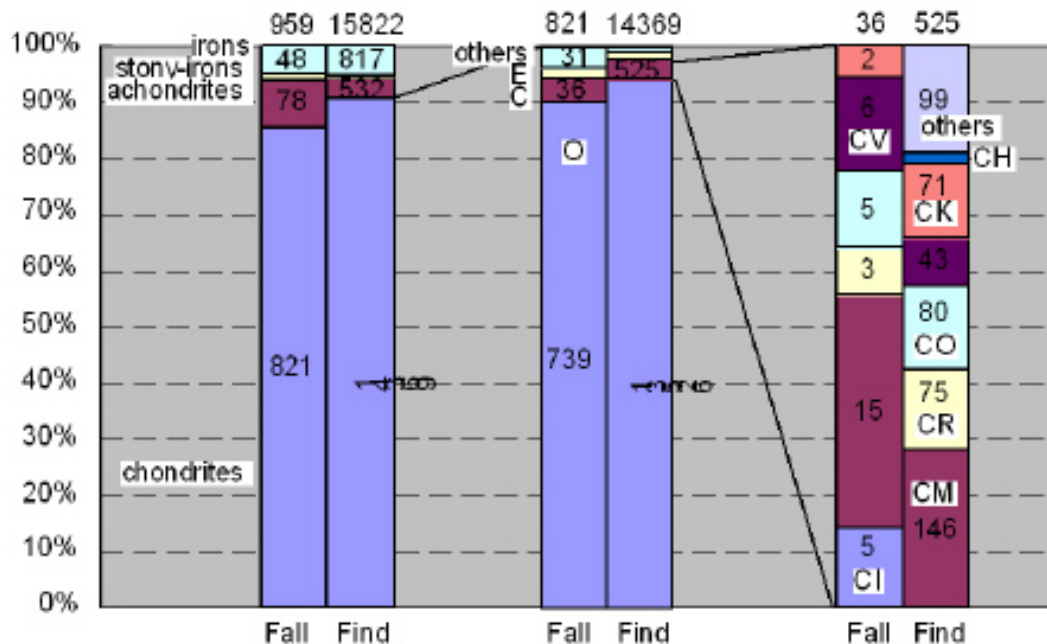


Onion Shell

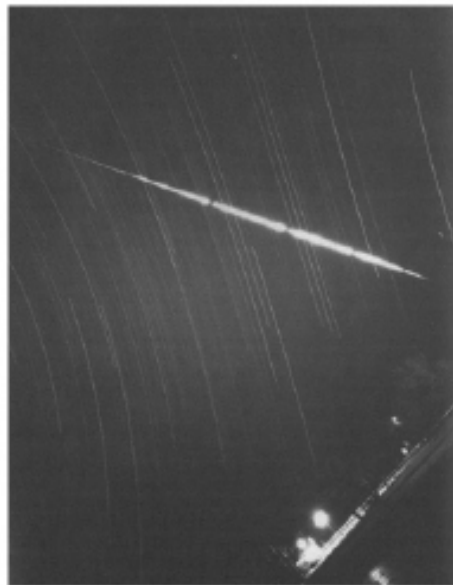
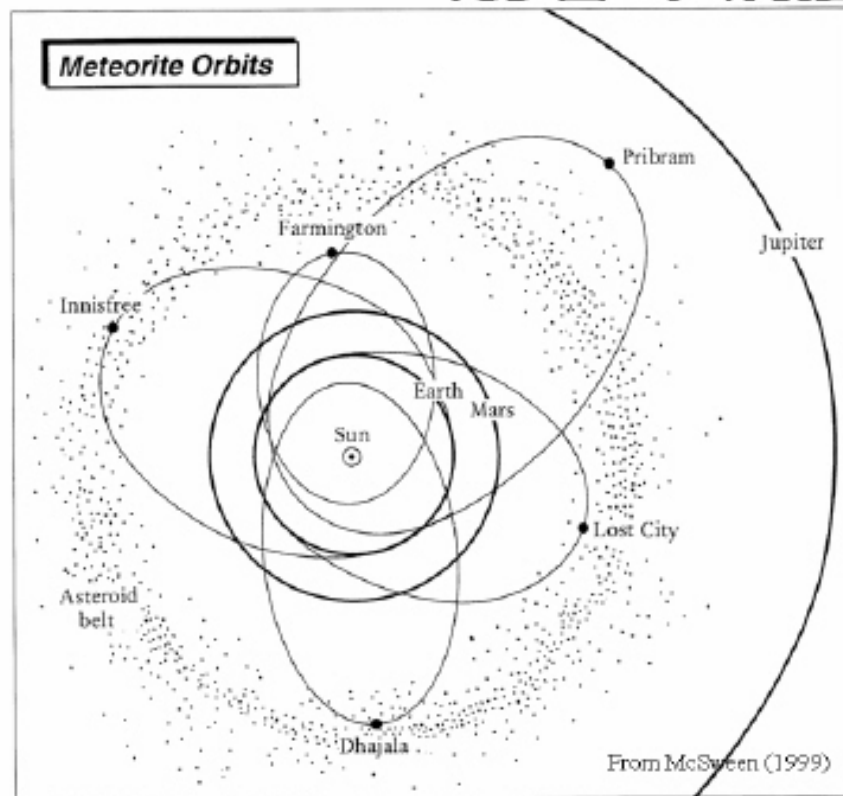


Rubble Pile

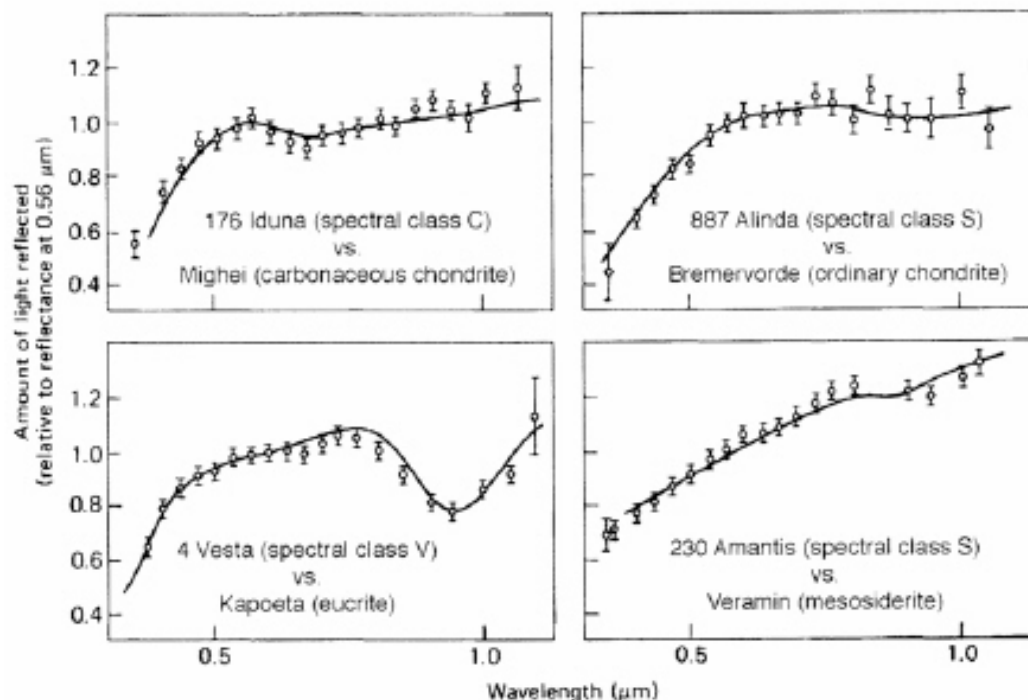
隕石の割合



隕石の軌道



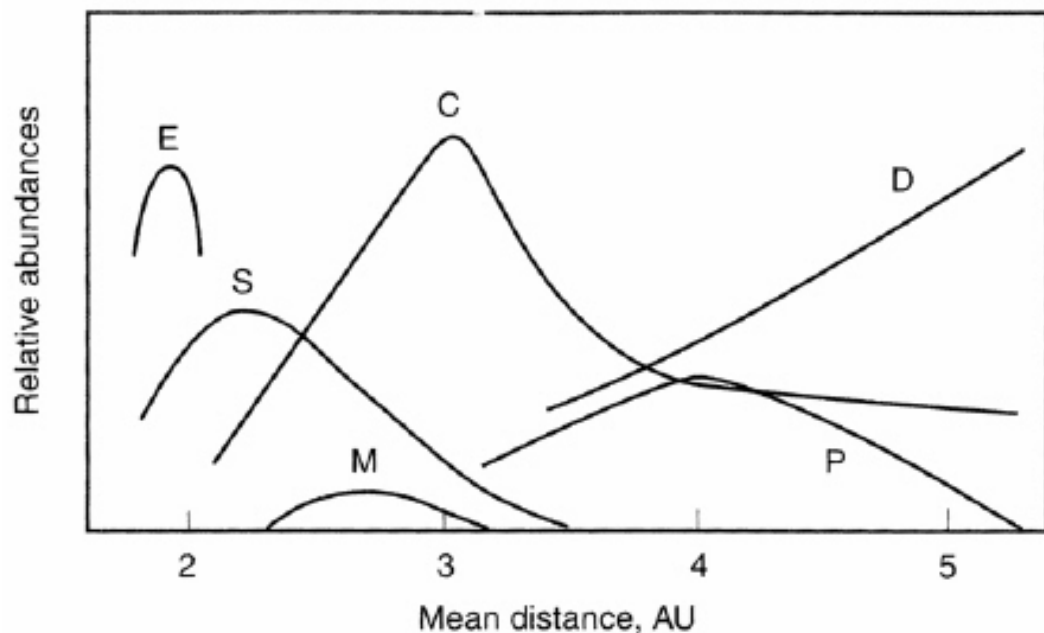
小惑星の反射スペクトル



From Chapman (1976)



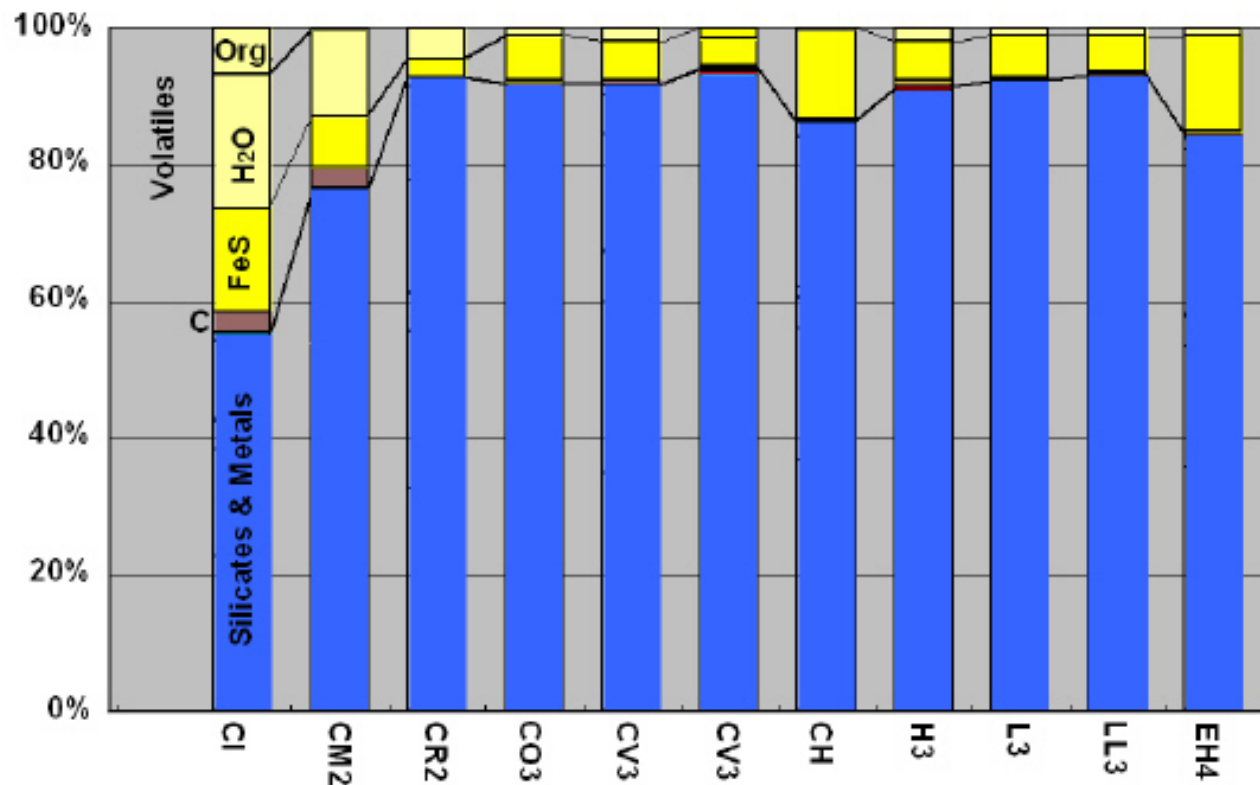
小惑星タイプの動径分布



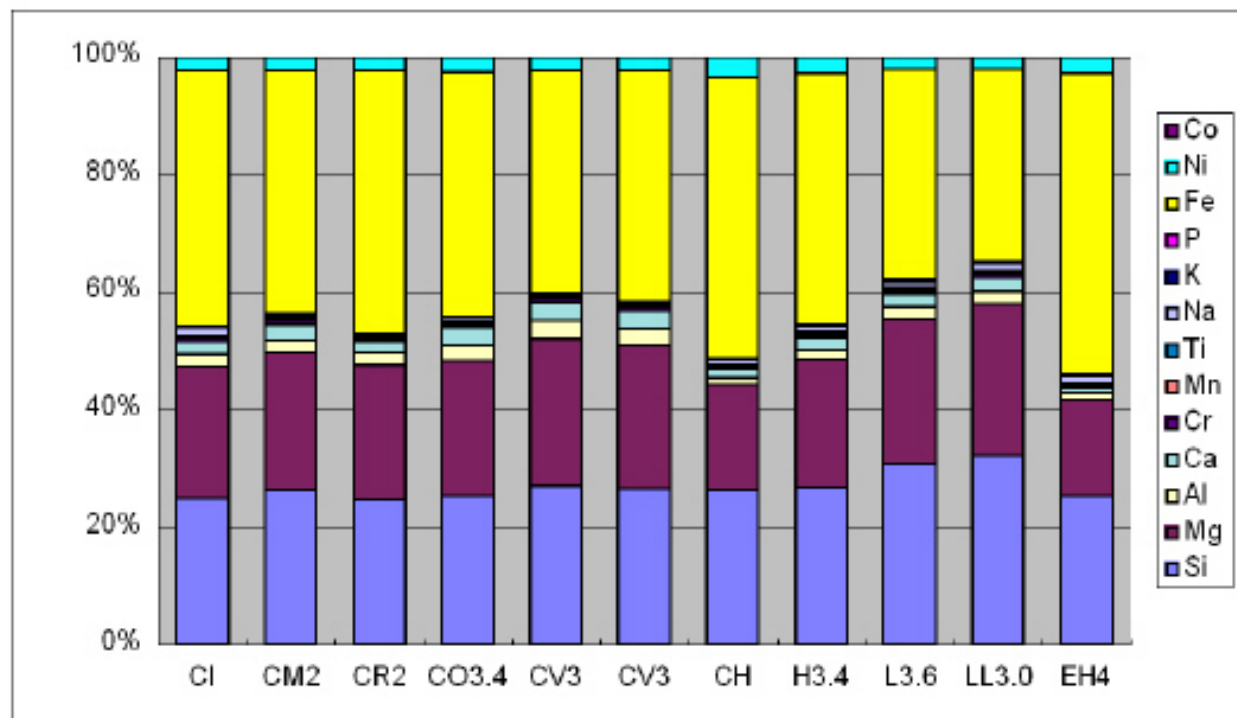
Chondriteの特徴

- コンドライトは種々の温度・場所・時代で形成した鉱物や分子の集合体
- 全岩化学組成はどれくらいばらついて
いるか？

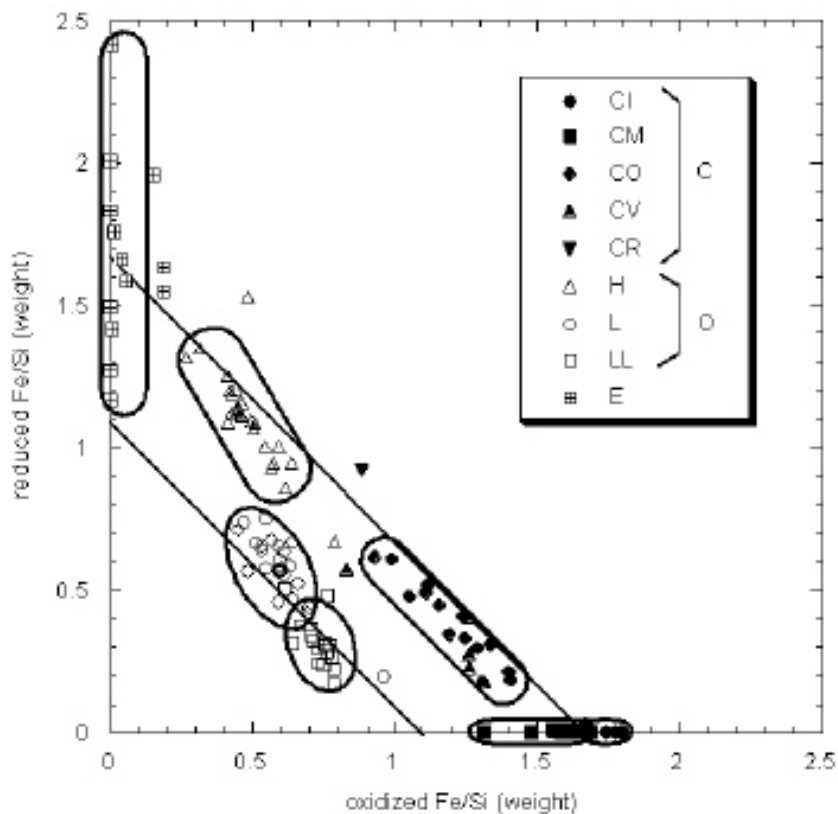
Chondriteの化学組成比較I



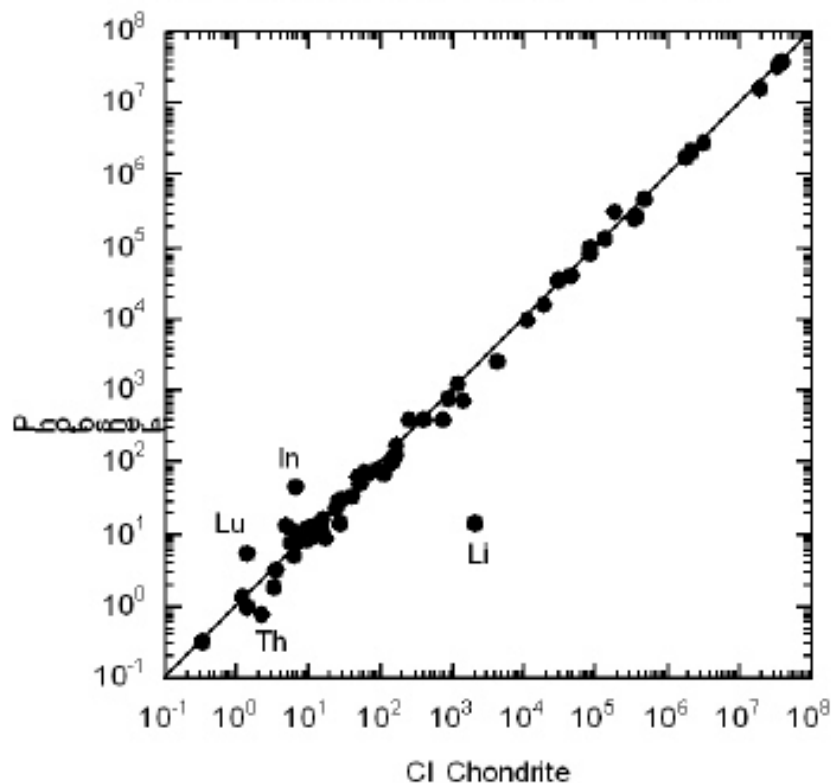
Chondriteの化学組成比較II

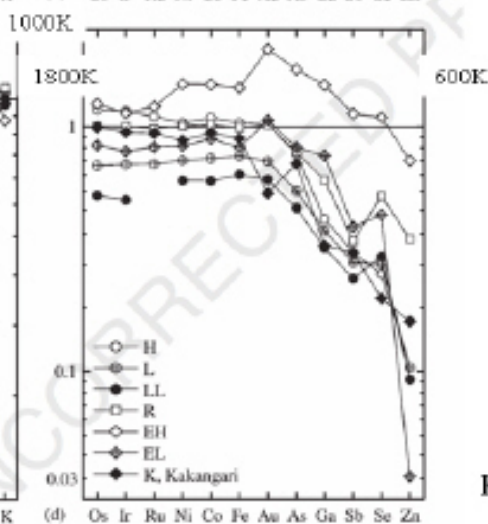
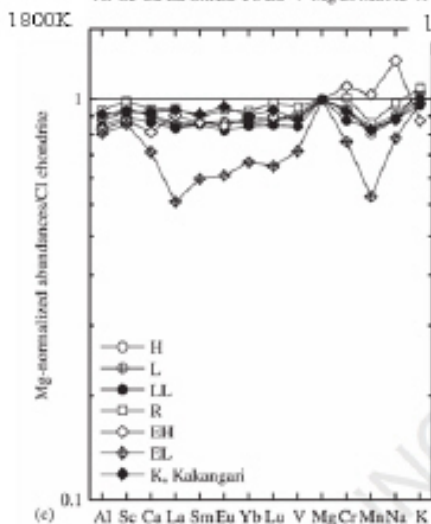
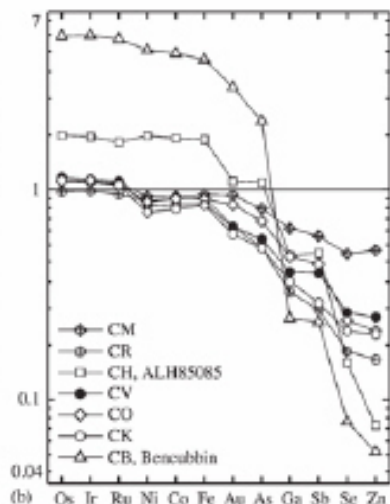
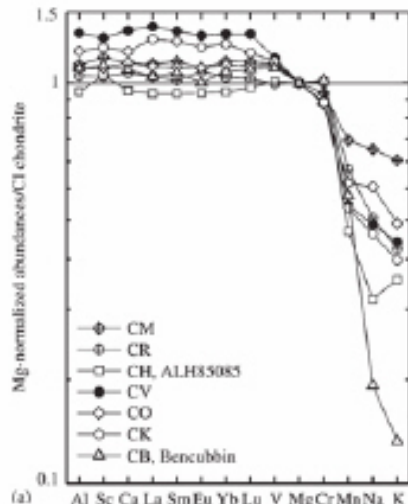


U-C diagram



Chondriteの組成





Chondrites

- 種々の温度($>2000\text{K} \sim <200\text{K}$)で形成した鉱物や分子からなる各構成要素の機械的集合体
- 揮発成分を除き化学組成はほぼ一定
 - 一見矛盾している関係
- 熱い星雲ガスの冷却と2成分混合
- 熱い星雲ガス存在の天文学的証拠なし
- 隕石中にも支持しない事実
 - 同位体異常, プレソーラー粒子