RECORDS OF EARLY CRYSTALLIZATION IN THE PROTOPLANETARY DISK.

A. Vitrano[1*], F. Foresta Martin[2], P. M. Nuccio[1], F. Lucci[3], S. Bernardini[4], G. Della Ventura[4], L. Tortora[4], V. Graziani[5], M. Nazzari[6], S.G. Rotolo[1].

[1]Università degli Studi di Palermo, Italy. *(Via Archirafi, 22. 90123. Palermo. andrea.vitrano@gmail.com; andrea.vitrano02@you.unipa.it).

[2]INGV, Palermo, Italy. [3]Università degli Studi di Bari Aldo Moro, Italy. [4]Università degli Studi di Roma Tre. Roma, Italy. [5]INFN sez. di Roma Tre. [6]INGV, Roma, Italy.

Introduction

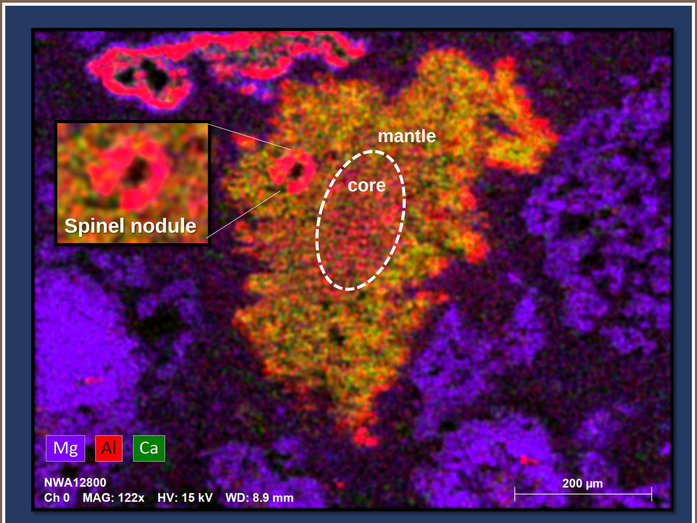
Carbonaceous chondrites consist of agglomerated primitive components formed during the evolution of the Solar nebula. Notably, **calcium-aluminum-rich inclusions (CAIs)** represent frames of the genesis of primitive carbonaceous chondrites, that can tell us significant steps of the early formation of planetesimal whitin our protoplanetary disk.

This study is focuses on the preliminary investigation of the CV3 carbonaceous chondrite NWA 12800.

Methods

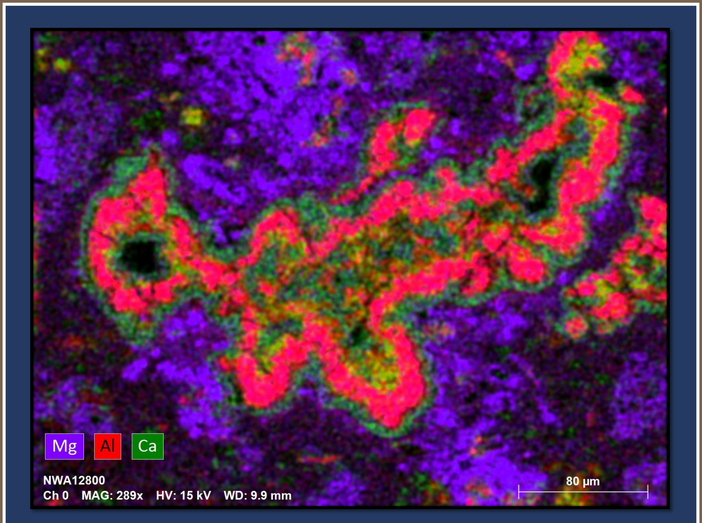
- Scansion Electron Microscope: Zeiss Sigma 300 FE-SEM equipped with an HDBSE detector and a QUANTAX 60x60 mm^2 detector for EDS.
- Electron probe microanalyses: Jeol JXA 8200 electron microprobe.

Mineralogical phases were inferred according to chemical composition obtained from EDS and EMPA analysis.



① First condensation

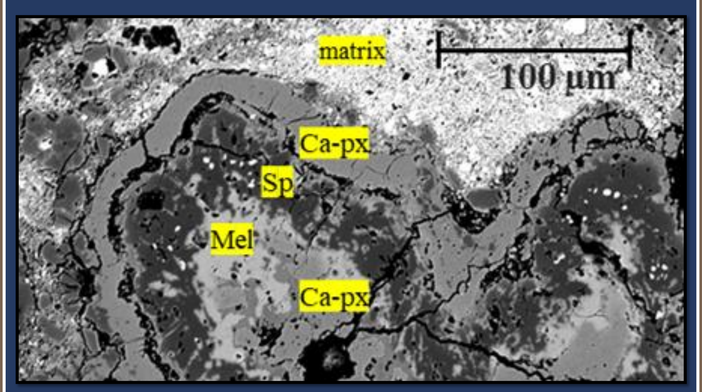
Combined X-ray elemental map in Mg, Al and Ca of a fluffy CAI displaying a **core-mantle structure**. This texture is interpreted as a direct condensation sequence from nebular gas, following transportation to different regions of the protoplanetary disk [1]. At a pressure of 10^{-3} bars gehlenitic melilite core condeses in the range of temperatures of 1,630-1,450 K and diopside-grossmanite mantle in the range of 1,450-1,400 K [2]. Spinel nodules are also present and dispersed in the mantle.

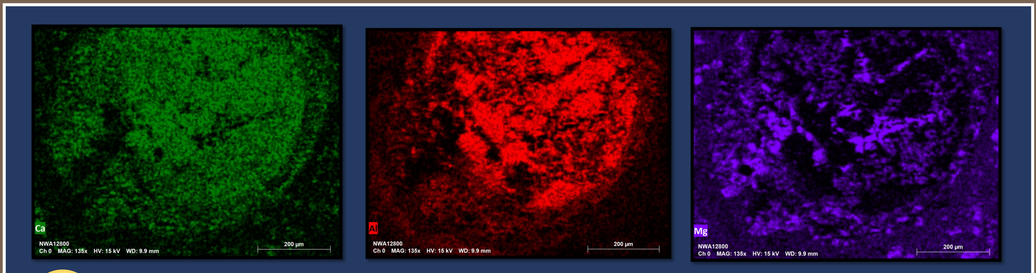


② Flash heating

In some CAIs diopside core is enveloped by a sequence of mono-mineral rims. These rims were formed as a result of very brief, intense heating events in the solar nebula.

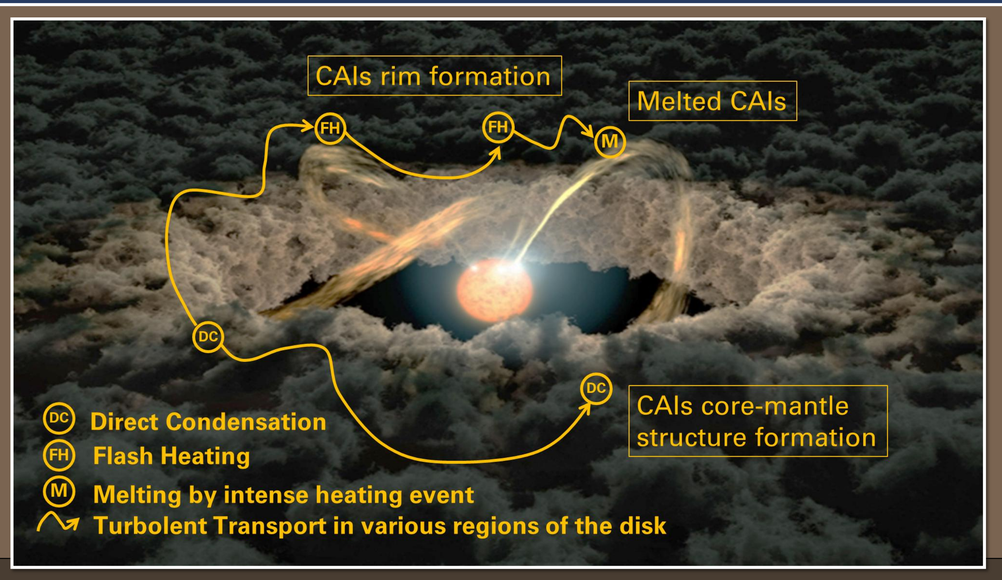
Although some elements might have been partially lost by vaporization, sub-solidus diffusion of Mg, Si and Ca, etc forming mono-mineral rims whilst the CAI was still in the nebula [3-5].





③ Complete melting

Other refractory inclusions are coarse-grained and composed of pyroxene-melilite-spinel-anorthite-rich spherules known as Type Bs [6] formed as molten droplets (see fig. above showing combined X-ray elemental map in Ca, Al and Mg). Dynamic crystallization experiments on synthetic melts of Type B CAIs demonstrate that these CAIs experienced melting temperatures in the order of 1,700–1,800 K and cooled down at rates of a few tens of degrees per hour [7].



❖ Preocesses affecting CAIs, after their tutbulent transportation to different areas of the protoplanetary disk, characterized by changes in temperature, very short intense heating events or extreme high temperature. *(Image of protoplanetary disk from NASA/JPL-Caltech.)*

Conclusion

The investigated CAIs show records of complex processes of direct condensation, aggregation and melting of refractory minerals, occurred in various regions of the solar nebula. They are characterized by different temperatures and mineralogical stability conditions. Sometime nebular lightning, magnetic reconnection flares and gas dynamic shock waves events lead to complete melting of CAIs, giving rise to subsferical objects, before these were trapped in a carbonaceous matrix together with chondrules.

Further investigations are still in progress.

References

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