Introducion: Dark clasts (DCs), also known as dark inclu-
sions, are common in CV3 chondrites. DCs commonly contain
rounded aggregates consisting mainly of fine-
grained Fe-rich ol-
vine. Previous researchers [1–3] suggested that DCs have under-
gone aqueous alteration and thermal metamorphism on the me-
eteorite parent body, and the aggregates in DCs are pseudomorphs
of chondrules and CAIs. However, mineralogy and variations of
pseudomorphs in DCs remain poorly characterized. Here, we pr-
eent the results of SEM (back-scattered electron) and TEM ob-
servations of pseudomorphs in two DCs (DC1 and 2) in Allende.

Results and Discussion: In SEM images, DC1 (88 mm² in
area) consists mainly of fine-grained Fe-rich olivine and appears
featureless. However, our observations in transmitted light reveal
that DC1 contains numerous pseudomorphs, which have been
almost completely replaced by fine-grained minerals. The pseu-
domorphs range in diameter from 20–850 μm, but most are
<250μm; their sizes are much smaller than the chondrules in the
host meteorite. We found ten large pseudomorphs (>400 μm).
All of them are surrounded by opaque rims (20–250 μm in thic-
ness), whereas most of the smaller pseudomorphs have no rims.

SEM observations reveal that the ten large pseudomorphs al-
so consist largely of fine-grained Fe-rich olivine but nine of them
have distinctly higher abundances of particular minerals com-
pared to the surrounding materials, and they can be divided into
three different types: 1) diopside-hedenbergite-rich, 2) nepheline-
sodalite-rich, and 3) pentlandite-awaruite-rich. Most of these par-
ticular minerals are typical products of hydrothermal alteration.
The differences in mineralogy between the pseudomorphs proba-
bly reflect the differences between precursor chondrules.

Fine olivine grains in DC1 generally contain submicrom-
eter-sized opaque inclusions and voids. TEM observations reveal
that the inclusions are pentlandite and awaruite. We found that the
olivine grains in the rims around the large pseudomorphs are
smaller in size and contain more abundant micro-inclusions than
those in other areas.

DC2 (19 mm²) also consists mainly of fine-grained Fe-rich
olivine, but some chondrules preserve coarse-grained pheno-
crysfts, which indicates that DC2 has been less altered than DC1.
We found some pseudomorphs are composed of fine-grained di-
opside-hedenbergite, andradite, kirschsteinite, wollastonite, and
calcite. We infer that the precursors of these pseudomorphs are
CAIs. The presence of calcite strongly suggests that DC2 experi-
enced hydrothermal alteration.

These results are consistent with that the pseudomorphs were
formed by replacement of chondrules and CAIs under a hydro-
thermal condition. The precursor of DC1 is clearly different from
host Allende. The absence of rims around the majority of smaller
pseudomorphs suggests that the smaller pseudomorphs were
fragments of larger chondrules before alteration of the precursor
lithology.