EFFECTS OF LOW MELTING-TEMPERATURE COMPONENTS
ON THE LITHIFICATION OF PLANETESIMALS AND METEORITES

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In the early evolutional stage of chondrite parent bodies and planetoids,
mode of collision depends on the impact strength of kilometer-sized plane-
tesimals (1). Planetesimals are thought to be loosely consolidated aggregates
of silicates and low melting-temperature materials (2). Mechanical properties
of such aggregates are significantly influenced by the presence of fine
grains filled in the grain boundaries (3). Variations of strength for loosely
consolidated aggregates can be represented by the degree of fragmentation or
the critical impact velocity in the low-velocity impact experiments (4). In
this paper, we report the effects of water-ice and glassy components on the
increase of the impact strength of loosely consolidated aggregates, which
may simulate mechanical properties of planetesimals.

Spherical projectiles of about 1.5 cm in diameter were made from olivine
(or peridotite) powder mixed with various amounts of water and/or soda glass.
Then projectiles are left for more than half a day under various temperatures.
To represent the degree of the lithification, we use the critical impact
velocity at which the largest fragment equals a half of the original mass.
The critical impact velocity of the olivine+ice projectiles freezed at -22°C
increases from that of dirt clods to that of pure ice, as the water (ice)
content increases (Fig. 1.). As porosities of the projectiles are more than
30 %, the addition of 5 wt% of ice does not fill up the pore space and ice
will only cement the contact of grains.

Fig. 2. shows the critical impact velocity of the olivine + soda glass
(20 wt%) projectiles heated at various temperatures. A large increase of the
critical impact velocity corresponds to the annealing temperature of soda
glass. The viscous deformation of glassy material will increase the grain-to-
graın adhesion. Fig. 3. illustrates the effects of albite composition glass
(Abs.) and serpentinite (Srps.) on the impact strength instead of soda glass.
Mass ratios of the largest fragment to that of the original are plotted as
a function of impact velocity (3). Dotted lines are the data from (4). For
projectiles of olivine + Srps., Abs., and Soda, heated temperatures were 700°C
Dehydration of serpentinite slightly increase the impact strength. As the
annealing temperature of albite glass is far higher than 700°C, no significant
increase of the impact strength is obtained.

The lithification of aggregates will proceed by a) the melting and sub-
sequent solidification of low melting temperature materials and b) the defor-
mation and grain-to-grain adhesion of glassy materials. The melting and sub-
sequent solidification of ice will occur in the impact process of icy material
which would be common in the formation process of chondrite parent bodies and
planetoids. The strength of such aggregates would become as high as that of
pure ice. Reduction of the rebound coefficient in the collision of icy material
by this process has been reported (5). Variations of the strength among chond-
rites may partly due to the heterogeneous deformation of glassy and amorphous
material at the grain boundaries (6). The surface of chondrite parent bodies
and planetoids would also lithified by the implantation of small projectiles
due to the grain-to-grain adhesion by such mechanisms.
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Fig. 1. Critical impact velocity vs water (ice) content for olivine+ice aggregates, freezeed at -22°C. Data of dirt clods and ice are from (4).

Fig. 2. Critical impact velocity vs heated temperature for olivine+soda glass aggregates. Arrow shows the annealing temperature of soda glass.

Fig. 3. Mass ratios of the largest fragment to the original mass vs impact velocity. For olivine + Soda, Srp., and Ab. aggregates, projectiles are heated at 700°C, for olivine + H_2O (ice) aggregates, freezeed at -22°C. Data of dirt clods, ice (pure), and basalt are from (4).

REFERENCES

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