LYOLUMINESCENCE AND SURFACE INTERACTION PHENOMENA OF LUNAR FINES.
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Since lunar surface materials have remained in a dry environment for
several aeons, it was thought likely that they might exhibit 'lyoluminescence'
(emission of light during dissolution) on being dissolved for the first time
in the laboratory. In this communication we summarize the results of some
preliminary experiments in this area. These investigations form a logical
extension of our work on lunar thermoluminescence (TL; see, e.g., ref. 1) as
well as on lyoluminescence (LL) of various materials (2,3).

It is known from TL experiments that surface samples of lunar fines and
rocks have received large amounts of radiation from solar flares and cosmic
rays. This leads to natural (or 'equilibrium') doses ranging from \( \sim 10^5 \) to \( \sim 10^6 \)
rad being retained in the high-temperature (300-550°C) TL glow structure (1).
Since a relationship exists between TL and LL, it was decided to study LL in
the Apollo 15 fines sample 15261,70, which had been shown (4) to have retained
not only a natural dose of 1.2 Mrad in the 300-500°C readout interval but also
a substantial amount of TL in the low-temperature (\( \sim 100 \) to 250°C) region. This
is because this sample had been collected from the bottom of a trench \( \sim 20 \)
cm deep, and had thus remained at a low effective temperature (\( \sim 18 \) \( \pm \) 5°C; cf.
ref. 4).

As a preliminary to the lunar investigation, a terrestrial rock sample
with a quasi-lunar composition was studied, using the proposed technique.
This was a sample of a basic Greenland rock (containing plagioclase, diopside,
pyroxene, and hornblende; and \( \sim 2 \times 10^9 \) yr old), ground and sieved to yield a
fraction \(<150 \) \( \mu \)m. The sample, both in its natural state and after irradiation
with Co-60 \( \gamma \)-rays (to a dose of 1 Mrad) was dropped into water, but no light
emission was detected by the highly sensitive photomultiplier system of our LL
equipment. However, when the same (natural) material was immersed in an
aqueous solution of luminol (3-aminophthalic acid hydrazide), which is a
chemiluminescent indicator, a light signal was received, which lasted for over
50 minutes (Fig. 1). The light output was enhanced by a factor of \( \sim 10 \) when
the natural sample had received an additional dose of 1 Mrad of \( \gamma \)-rays before
immersion. When the irradiated sample was annealed at 600°C for 5 hr (which
should drain all TL), the subsequent LL light output was less than from the
natural sample.

Next, the lunar sample 15261,70 (sieved to yield a grain size \( \leq 63 \) \( \mu \)m,
was subjected to the same procedure. While the natural and irradiated moon
dust showed some light emission when it was wetted with luminol solution,
annealing of the irradiated sample produced unexpected and surprising results
on immersing it in luminol (see Fig. 2). Thus, when the sample which had

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received a 1 Mrad γ-ray dose was annealed at 150°C (chosen to simulate lunar daytime temperature) for 5 hr in ordinary room atmosphere, the resulting LL signal was actually enhanced. The light output was even greater when the post-irradiation annealing had been carried out at 600°C (also for 5 hr), as is seen in Fig. 2.

We believe that the effects observed are associated with the surface states (5). Oxygen is chemically adsorbed by metal oxides in the form O, which requires the transfer of electrons from the solid, thus creating holes (6). If a crystal is irradiated, certain changes in electron states are introduced. When such a crystal is immersed in pure water, electrons bound in surface defects are expected to undergo a very slow hydration process. If a hydrated electron encounters an acceptor in the form of a hole or a luminous centre, light emission may take place (LL).

In the case of interaction of the solid sample with luminol solution, the oxidation process will play a dominant role in the emission of light. Oxidation requires the transfer of an electron from a luminol molecule to an acceptor (e.g. O₂) in the solid sample. As chemisorbed oxygen on the crystal exists as O, it would repel the donated electron from the luminol molecule. It follows that if oxygen is involved in the emission of light, the effect of radiation may well be to convert it back to O₂ molecular form, which is rapidly physically adsorbed since this process requires no activation energy. The lunar samples, having remained unexposed to free oxygen on the surface of the moon for geological time-periods, will react with room oxygen much more vigorously (especially at high annealing temperatures) than their terrestrial counterparts. This would lead to enhanced light output on solution.

Holmes et al. (7) have reported the strong interaction of gases with lunar fines. The adsorption of water vapour, especially at high relative pressures, and the result of prior outgassing or 'activation' of the sample at elevated temperature, are particularly important in this context. These authors point out the importance of high radiation damage of natural lunar material, which leads to higher solubility. These considerations have an obvious bearing on our observations. We propose to check some of these effects by heating lunar samples in vacuum or in a reducing atmosphere. Lunar samples kept in an inert atmosphere (e.g. N₂) since receipt, as well as those kept in deep freeze and at dry-ice temperature (8) should prove valuable in this respect.

References
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**Fig. 1.** Immersion in luminol solution (125 mg luminol, 1.25 g Na₂CO₃, 2.5 mg Chorohemin in 1 litre deionized water).

- TERRESTRIAL ROCK (Greenland)
  - 1: Natural
  - 2: Natural + 1 Mrad
  - 3: Natural + 1 Mrad, Annealed at 600°C, 5 Hr

- MOON DUST (15261, 70)
  - 1: Natural
  - 2: Natural + 1 Mrad
  - 3: Natural + 1 Mrad, Heated to 150°C, 5 Hr
  - 4: Natural + 1 Mrad, Heated to 600°C, 5 Hr

**Fig. 2.** Immersion in luminol solution

- { grain size: <150 μm }

- { grain size: <63 μm }

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