

Biological Effects of Raw and Processed Oil Shale Particles in the Lungs of Laboratory Animals

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Environmental and occupational health concerns will have an effect on the developing oil shale technologies. The mining and crushing of large volumes of rock will be a characteristic of at least some of these technologies, and above ground disposal of processed shale will require adequate control measures. Exposure by inhalation to the dusts that may arise from shale oil technologies may present a hazard both in the work force and in the local population. Animal studies dealing with the effects of oil shale-related materials in the lung are in progress. Experiments involving Syrian hamsters exposed by inhalation and by intratracheal instillation are described.

Full utilization, for energy production, of the extensive oil shale deposits of the intermountain west is dependent upon the development of economically competitive production technologies. Health and environmental concerns will play a major role in the development of these technologies because of the possible imposition of extensive pollution control measures and occupational health regulations. In general, the fuel extraction methods under current study include above-ground retorting, wherein mining, milling, and transport are major operations; *in situ* retorting wherein no mining or milling takes place; a combination of above ground and *in situ*, wherein mining and milling is less extensive but some of the shale is retorted above ground. With the exception of the true *in situ* method, all of the current technologies will produce large volumes of processed shale with the attendant problems of controlled disposal.

No threshold limit values (TLV) have been established for oil shale and its process products except for the application of numbers based upon standard formulas for silica-bearing materials (1). Dust exposure becomes an important occupational health concern when the relatively high free silica content (8-12%) is considered together with the organics present in oil shale and its byproducts (2).

Studies involving the response of pulmonary tissues to the various oil shale derived materials thus become of first-order importance to the development of larger scale production technologies.

The work reported here deals with the exposure, by inhalation and intratracheal instillation, of laboratory animals to several oil shale-related materials.

Materials and Methods

All of the animals in the studies were Syrian hamsters obtained from Engle Laboratory animals of Hammond, Indiana. They were maintained in filtered plastic cages, fed standard hamster diet, and given water *ad libitum*.

The raw shale originated at Anvil Points, Colorado, and together with the modified *in situ* processed shale was obtained from the Laramie Energy Research Center (LERC). The Fischer Assay (3) processed shale was obtained from the TOSCO Corporation, Golden, Colorado. The materials were ground to a fine dust by ball milling, and the aerosols were generated with a Wrights dust feed (4). Total mass concentrations were established by using gravimetric methods following a standardized sampling time at a set flow rate. Respirable mass was established by using a cyclone apparatus.

Hamsters undergoing inhalation procedures were individually housed in open wire mesh cages placed

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Table 1. Inhalation exposure groups.

Experiment	Material ^a	Concentration, mg/m ^{3b}	Exposure	Animals ^c	
				Experimental	Control
7-1-1	Raw shale	13	4 hr/day; 4 days/wk; 4 wk	25	12
7-1-2	Raw shale	33	4 hr/day; 4 days/wk; 4 wk	54	20
7-1-3	Retorted shale	24	4 hr/day; 4 days/wk; 6 wk	80	20
7-1-4	Retorted shale	150	14 hr in 24	12	0

^a Source: Laramie Energy Research Center (LERC).

^b Respirable mass.

^c Syrian hamsters.

in the inhalation chamber during the actual exposure. Control animals were subjected to the same conditions in an adjacent chamber without the aerosol.

Intratracheal instillations were administered with the hamsters under sodium methohexital anesthesia. The materials to be instilled were suspended in 0.2 ml of physiological saline and administered by direct intubation of the trachea. The shale products used in the intratracheal studies were identical in preparation to those used for inhalation.

Complete necropsies with histological examination have been performed on all animals that have died. Some lung sections from sacrificed hamsters were used to study ultraviolet fluorescence as a means of locating and identifying the shale materials in the respiratory tract.

Results and Discussion

Inhalation exposures of Syrian hamsters to both raw and retorted shale are summarized in Table 1. As a pilot experiment, half of the animals in group 7-1-1 were used for serial sacrifice in an effort to study early lung response and hematological values. Total white blood cell counts, differential counts, red blood cell counts, packed cell volumes and hemoglobin values did not differ significantly from control animals during or after exposure. Early histopathology observations on the inhalation ani-

mals have shown a minimal response to the oil shale materials, with a slight increase in macrophage activity being the only change noted. Under the conditions of exposure used, the deposition in the deep lung appears to be slight with most of the material found near the termination of respiratory bronchioles (Fig. 1).

A summary of the intratracheal exposure groups is shown in Table 2. Animals in Groups 7-1-7 and 7-1-8 were used for the study of UV fluorescence of the organic material in shale (Fig 2.) The fluorescence of the LERC-modified *in situ*-retorted shale was considerably brighter than that of the Fischer assay material. Since LERC material is processed as large rock in the 150 ton retort, it is probable that more organic material remains behind in the spent material than when the Fischer assay retorting method is used. Our first observations suggest that fluorescence techniques may be useful for the study of macrophage response and the mechanisms responsible for foreign body elimination.

Groups of animals are being exposed to quartz dusts as positive controls for fibrogenic response but are not reported here because the studies were started at a later time.

Animals receiving the shale materials intratracheally exhibited a more intense macrophage response in foci located near the bronchiolar terminations (Figs. 3 and 4). An epithelial response resembling bronchiolar adenomatoid proliferation was observed in one hamster which had received only two 5 mg doses of modified *in situ* processed shale at weekly intervals (Fig. 5).

Very few animal studies with oil shale connected materials have been performed, even though interest in shale oil extraction has existed for a number of years. The most significant recent experiments using *in vivo* systems have been described by Coomes (5). In one of these experiments performed for TOSCO Corporation a rather unique "total exposure" technique was used in which mice were exposed to various shale materials as bedding. This approach exposed the skin, eyes, respiratory tract and alimentary system in one experiment. The other study performed for TOSCO utilized standard skin

Table 2. Intratracheal exposure groups.

Experiment	Material	Dose, mg	Frequency/ time	Animals ^a
7-1-7	Retorted shale, Fischer assay	5	Daily for 4 days	20
7-1-8	Retorted shale, LERC	5	Once	6
7-1-9	Retorted shale, Fischer assay	5	Weekly for 7 wk	20
7-1-10	Retorted shale, LERC	5	Weekly for 7 wk	24
7-1-12	Raw shale, LERC	5	Daily for 4 days	25

^a Syrian hamsters.

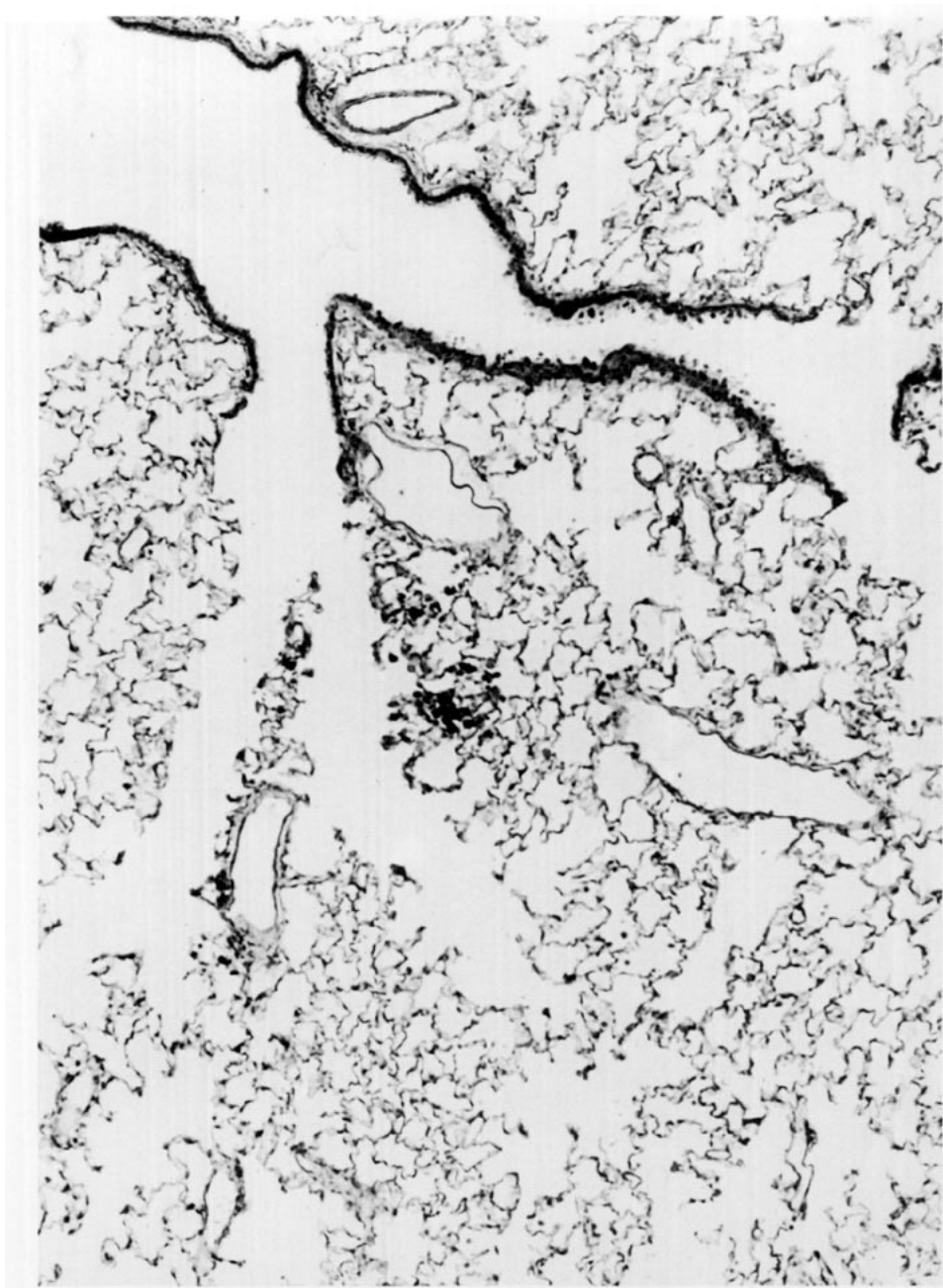


FIGURE 1. Raw oil shale particles in a hamster lung following inhalation.

painting and intratracheal techniques. Both studies are nearing completion and should provide useful data.

Studies of the pulmonary response elicited by

animals exposed to various oil shale materials will be of primary importance in establishing controls and standards of exposure for this developing industry.



FIGURE 2. UV fluorescence of modified *in situ* processed shale after intratracheal instillation. The background structure is lung parenchyma. The large bright object is a shale laden macrophage.

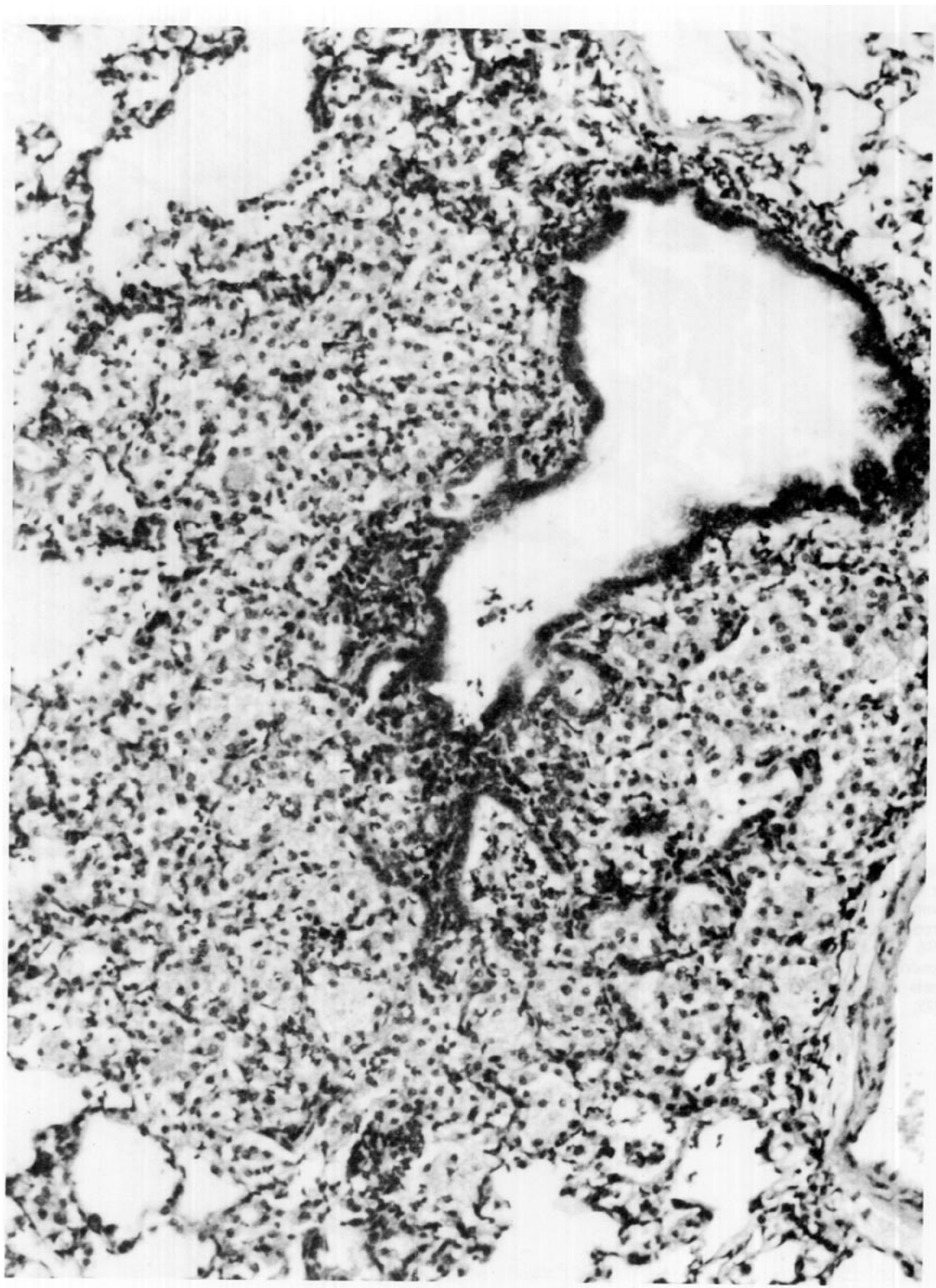


FIGURE 3. Accumulation of macrophages and other cells around a bronchiole in a hamster lung following intratracheal intubation with raw oil shale. Only small numbers of shale particles are shown.

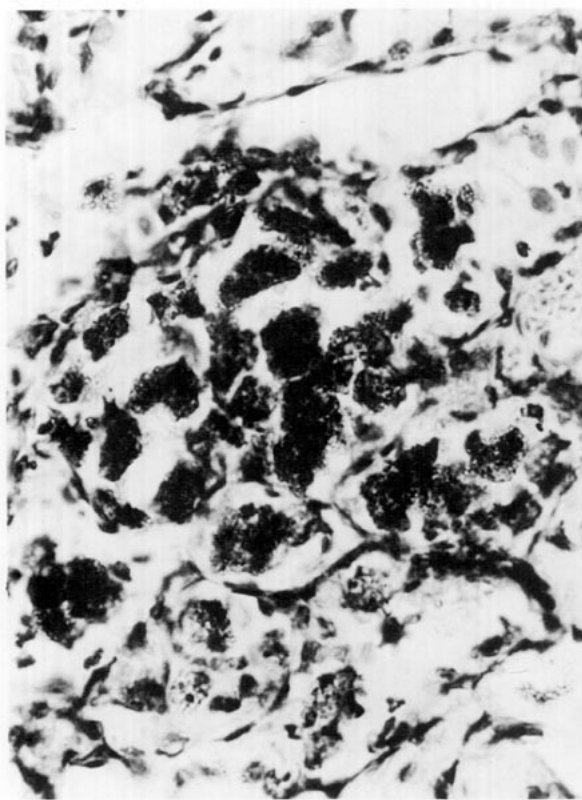


FIGURE 4. Higher power photomicrograph of oil shale laden macrophages within alveoli following intratracheal intubation.



FIGURE 5. Mild epithelial response associated with raw oil shale particles near the terminus of a respiratory bronchiole.

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