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... most of the elements in the center of the periodic table, such as the transition elements. Finally, when the ionic potential is high (> 10) the positive ion appropriates one or more oxygen ion, freeing the hydrogen and forming an oxyanion, which is generally soluble; this is characteristic of the nonmetals in the upper right corner of the periodic table.

If life began in the primitive terrestrial oceans, elements whose abundances in the aqueous phase are high should have a high representation in living material. In Fig. 1, the enrichment factor for a number of elements—that is, the ratio of the concentration of the element in an organism to its concentration in the earth's crust (*7*)—is plotted against ionic potential. A similar curve is seen for all major groups of organisms, as we proceed up the evolutionary scale from bacteria to fungi to plants to land animals, and for the ocean (Fig. 2).

A general pattern is observed for all living organisms: (i) For elements of low ionic potential values ($IP < 3$) the log of the enrichment factor (EF) is in the range of −1 to +1 indicating small enrichment or small depletion relative to the crust. (ii) For intermediate IP values ($3 < IP < 10$) log EF is −3 to −4 indicating large depletion in living organisms. (iii) For large IP values ($IP > 10$) log EF increases as the ionic potential increases and varies from −4 to +4. It should be noted that the elements mentioned by Crick and Orgel as showing anomalous distribution patterns—Mo, Ni, and Cr—also follow this general pattern. Specifically, Mo does not show any significant enrichment in living organisms as compared to the earth's crust. Obviously, taking each element and each group of organisms separately, we may expect many exceptions to the rules; still, the general pattern is strikingly similar for all the groups of organisms investigated.

According to Oparin (*8*), some combinations of biochemical reactions are characteristic of all contemporary organisms. These are combinations of patterns acquired by the emerging living matter in its very early stages of development, before further specialization and differentiation took place. Thus the basic similarity of the elemental composition pattern of all groups of living organisms (Fig. 1) indicates that the pattern was determined at the initial steps of the development of life.

It should be noted that in the range of ionic potentials higher than 10, where the major biochemical elements sulfur, carbon, and nitrogen are found, organisms have a very significant enrichment of 10 to most 10,000 relative to the ocean. This

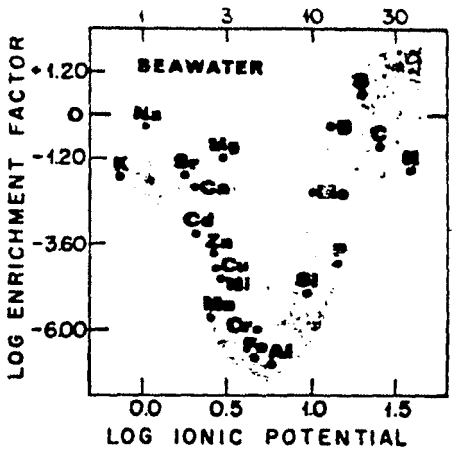


Fig. 2. Elemental enrichment factors in seawater, related to the ionic potential of the elements.

may be taken as a clue to a more exact location for the origin of life. It can be speculated that life began at the interface of the primitive atmosphere and the ocean, in the thin microlayers at the surface of the ocean where large enrichments of the atmospheric constituents (mainly nitrogen and carbon at that stage) may occur. Various other elements may also be concentrated in these microlayers because of the effects of surface-active materials, surface tension, and the transfer processes between the liquid and the gaseous phase. In any event, it is evident that a chemical environment similar to the earth's ocean is sufficient to explain the elemental abundance relationships in living materials. A nonterrestrial explanation, especially one that has inadvantageous to the rapid development of life, is not justified.

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Exposure to Asbestos in the Use of Consumer Spackling, Patching, and Taping Compounds

Abstract. *Analysis of representative samples of spackling, patching, and jointing compounds, purchased at retail stores in the New York City area, has shown that some contain asbestos minerals as well as other biologically active substances. Measurements suggest that home repair work involving the use of such materials may result in exposure to dust at concentrations sufficient to produce disease.*

Spackling and drywall taping compounds consist of extremely fine-grained white powders or premixed pastes. Plaster of Paris is supposedly the major constituent, but other light-colored materials including clays, micas, quartz, talc, and ground limestone, supplement or replace the plaster in many formulations. Chrysotile is added to some products, apparently because these minute fibers act as reinforcing agents. The presence of amphibole asbestos in some products results from its natural occurrence in talc, carbonates, and other rocks used as raw materials (*1*).

Fifteen samples of consumer spackling and patching compounds were purchased at hardware stores in the New York City area, four in 1972 or earlier and the remainder in January 1974. We analyzed the samples for mineral phases by polarized light microscopy, x-ray powder diffraction, and transmission electron microscopy, with particular attention to quantitative determination of asbestos minerals. The spackling and taping compounds consist mainly of particles smaller than 3 μm in average diameter or length (Fig. 1). Particles of this size are generally too small to

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Table 1. Mineral content of consumer spackling and patching compounds and industrial drywall taping compounds.

Mineral phase	Frequency of occurrence of mineral phases	
	In 15 consumer spackling and patching compounds	In 10 industrial drywall taping compounds
Chrysotile	3 (5–10%)	9 (5–12%)
Tremolite	1 (4– 6%)	1 (5– 7%)
Anthophyllite	1 (10–12%)	
Talc	2	2
Quartz	9 (5–70%)	6 (10–30%)
Feldspar	1	
Pyrophyllite	2	
Mica	8	9
Kaolinite	5	7
Calcite	11	4
Dolomite	3	4
Plaster of Paris	7	6

be individually studied by polarized light microscopy, and identification is further confounded because these compounds commonly are mixtures of four or more different materials. The analytical use of the optical microscope with its limited resolution allows large numbers of fibers to go undetected. The asbestos minerals, in particular, are usually too fine-grained to identify. In such circumstances, x-ray powder diffraction may be used to identify and quantify the individual crystalline phases present in the mixtures.

In this investigation the amounts of asbestos present in spackling compounds was determined by comparison with dilution standards (*2*). Binary systems of chrysotile, tremolite, and anthophyllite asbestos in plaster of Paris ($CaSO_4 \cdot \frac{1}{2}H_2O$) were prepared at varying dilutions on a weight-to-weight basis. Diagnostic reflections for each of the asbestos minerals were selected. These reflections were step-scanned by x-ray diffraction at increments of 0.02° 2θ, where θ is the dispersion angle, over a goniometric interval sufficient to define a peak-to-background ratio for the diagnostic reflections. A digital printout of elapsed time in a fixed-count determination was used to prepare precise positions and profiles of the diagnostic reflections. The area above background, determined with a compensating polar planimeter, was taken to be proportional to the concentration. Details of the method have been presented elsewhere (*2*). Samples of spackling and taping compounds were prepared, analyzed, and measured under the same conditions as the dilution standards. Comparison of the results of known dilution standards with the samples permitted the amounts of asbestos to be estimated with approximately 20 percent reproducibility.

The presence of certain minerals may interfere with the detection or quantitation of chrysotile in spackling and taping compounds. For example, chrysotile and kaolinite have similar crystal structures and consequently similar x-ray diffraction patterns (*3*). However, electron microscopy can be used to corroborate the results of x-ray diffraction and to directly estimate the asbestos content of materials, since each mineral type has a characteristic morphology and electron diffraction pattern.

The results of the analyses of 15 consumer spackling and patching compounds are given in Table 1. Three of the samples were found to contain chrysotile asbestos, and two others contained tremolite and anthophyllite asbestos. Talc was a major constituent in two samples and pyrophyllite two. The crystal structure and physi properties of pryrophyllite are alm identical to those of talc; pyrophyllite m be considered the aluminum analog of ta Its biological activity is presently known. Quartz was a major constituent seven of the samples, and it was present two others in lesser concentrations. On t basis of the x-ray intensities of several m jor quartz reflections, including those 4.26, 3.34, and 1.817 Å, the amount quartz present is estimated to be grea than 10 percent in the seven samples. Op cal and transmission electron microsco have shown essentially all the quartz to of respirable size (< 5 μm). Both qua and talc can produce pulmonary fibro (silicosis, talcosis) (*4*). One sample co sisted largely of quartz with lesser amou of feldspar and anthophyllite. This may dicate that the source material for t product was an anthophyllite schist. T combination of talc with some tremol and quartz in another sample represent common mineral association typical commercial talc ore bodies.



Fig. 1 Electron photomicrograph of a cons spackling product. Large numbers of chryso fibers and fiber bundles are present. Granu particulates are clay, mica, and carbonate m erals.

Table 2. Asbestos fiber concentrations during use of taping compounds containing asbestos minerals. Multiplication of the number of fibers per milliliter by 10^4 gives the number of fibers per cubic meter of air, an amount which may be inhaled during 1 hour. An unstudied proportion of these fibers is retained and others are exhaled. Current (interim) regulations of the OSHA prohibit concentrations of 5 fibers per milliliter or more, longer than 5 μm, as a time-weighted average for workers. Concentrations above 2 fibers per milliliter will be illegal after 1976. Current regulations set a ceiling concentration of 10 fibers, longer than 5 μm, per milliliter of air.

Operations	Number of samples	Peak fiber concentration (fibers per milliliter)	
		Mean	Range
Pole-sanding (1 to 1.5 m)	10	10.0	1.2 to 19.3
Background (2.5 m), same room	3	8.6	3.5 to 19.8
Background (7.5 m), adjacent room	2	4.8	0.7 to 8.8
Hand-sanding (1 to 1.5 m)	11	5.3	1.3 to 16.9
Background (2.5 m), same room	2	2.3	2.1 to 2.5
Background (4.5 m), adjacent room	2	4.3	1.5 to 7.1
Dry mixing (1 to 1.5 m)	2	47.2	35.4 to 59.0
Background (3 to 6 m), same room	3	5.8	0.5 to 13.1
Background (5 to 10 m), adjacent room	2	2.6	2.1 to 3.1
Sweeping floor (3 to 15 m)			
15 Minutes after sweeping	1	41.4	
35 Minutes after sweeping	1	26.4	

Both optical and electron microscop analyses showed that the asbestos fib present in the samples ranged in leng from 0.25 to 8.0 μm. Most were shor than 5 μm in length, which is respirat size, yet they were not generally detect by optical microscopy.

The possibility of asbestos exposure d ing home construction and repair is dicated by the fact that drywall constr tion workers are exposed to signific concentrations of asbestos air co tamination. Mineralogical analyses of industrial drywall taping compounds sh that nine contain chrysotile, in concent tions ranging from 5 to 12 percent (weight) (Table 1).

We made measurements of peak asbestos air concentrations in the breathing zone of drywall construction workers, utilizing the standard technique of the National Institute for Occupational Safety and Health (NIOSH) for asbestos sampling and analysis (phase-contrast optical microscopy at × 430) (*5*). These air samples were also analyzed by transmission electron microscopy. Air samples were taken at various building jobs and job sites and included such operations as hand-sanding, pole-sanding, mixing of dry spackle with water, and sweeping after completion of such operations. Personal air samples were also taken in adjacent areas; such air samples, taken in the breathing zones of the operators, constitute measurements of their exposure to dust.

Table 2 shows that airborne concentrations of 5 fibers per milliliter of air or more, longer than 5 μm, are common during the use of drywall taping compounds containing asbestos. This exceeds the interim legal standard excursion set by the Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor. The OSHA standard calls for an 8-hour time-weighted average. The discontinuous nature of these operations suggests that the 8-hour sampling is inappropriate in that peak exposures in the present instance, under a range of application and cleanup operations, greatly exceed the maximum allowable excursions of 10 fibers per milliliter for a 15-minute interval.

These concentrations, determined by the NIOSH method, are only suggestive of the total asbestos exposure. Comparison of optical microscopic and electron microscopic analyses of asbestos fiber counts of identical samples showed that, for every fiber visible by light microscopy (×400 magnification), there were from 200 to almost 1000 that could be seen only at electron microscopic magnifications of ×25,000.

The background measurements in Table 2 suggest that in home repair work involving sanding of spackling compounds, members of the entire household or other occupants of a building may inhale asbestos fibers. This could occur during mixing, sanding, or cleaning up of debris. During mixing of drywall taping compounds, spackle is gradually poured from a bag into a bucket of water and the mixture is stirred until the desired consistency is attained. Fiber counts measured during mixing were found to be from 7 to 12 times greater than the current occupational standard. Detectable fiber concentrations were found in adjacent rooms during mixing, and fibers were still suspended in the room air at least 15 minutes after mixing had ceased. Personal air samples were taken after sanding was completed. The floors of the rooms and halls were swept with a hand broom, which raised a cloud of dust. Fiber counts could not be made on floor sweeping samples because the filters were too heavily laden to count. Samples were taken after 15 minutes had elapsed, and, in one case, 15 m away in another room. Measurements showed that significant concentrations of asbestos remained suspended and could pervade living quarters for a considerable duration of time after sweeping had ceased.

In summary, our analysis of 15 representative samples of consumer spackling, patching, and taping compounds has shown that five contained appreciable amounts of chrysotile or other asbestos minerals. Many contained substantial amounts of quartz, talc, and other minerals with disease potential. Optical microscopic analysis of personal air samples obtained during the use of asbestos-containing compounds showed concentrations frequently in excess of the current occupational standard of 5 fibers per milliliter, longer than 5 μm. Use of these materials in home repair work (for example, mixing, sanding, and cleanup) may expose the user (and other members of the household) to significant concentrations of asbestos.

Even more important, none of the 25 industrial and consumer spackling and taping compounds examined had warning labels or indication that they might contain toxic or hazardous materials. It is, therefore, recommended that potentially toxic or hazardous materials be eliminated from consumer spackling, taping, and wall-patching compounds as soon as feasible. As an interim measure, labels should be required on such products stating their content and providing instructions for the use of appropriate respirator protection and for safe cleanup procedures, including the disposal of waste materials.

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Water Wells as Possible Indicators of Tectonic Strain

Abstract. *Coseismic water level changes associated with the Izu-Hanto-oki earthquake of 9 May 1974 were recorded in 59 among 95 observation wells located in the districts of Tokai and Kanto, Japan. The spatial distribution of wells in which the groundwater level rose or fell is rather systematic. The areas in which these wells are located closely coincide with the areas of contraction and dilatation expected by the faulting. This strongly suggests a possible correlation between the observed changes in groundwater level and the tectonic strain. The results may indicate that the water level of wells is able to monitor at least acute coseismic strain changes.*

A destructive earthquake occurred on the southern tip of the Izu Peninsula, Japan, at 08:33 hours on 9 May 1974. The seismological data (*1*) are: epicenter, 34° 34'N, 138°48'E; depth of focus, 10 km; and magnitude, 6.9. The focal mechanism of the earthquake was a quadrant type with the maximum pressure axis in a nearly north-south and horizontal direction. Distinct earthquake faults appeared along the preexisting, dextral strike-slip faults trending in a northwest-southeast direction (*2*).

Coseismic changes in groundwater level caused by the earthquake were examined in 95 observation wells (*3*), located 50 to 210 km from the epicenter. These wells were drilled originally for the protection of groundwater resources and measurement of land subsidence. Most of the wells range in depth from 100 to 300 m, the shallowest and the deepest being 35 and 2150 m deep, respectively. Groundwater level changes were continuously monitored, in most cases, with recorders manufactured by the Nakaasa Sokki Co. The practical sensitiv-