

The

SPEX

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Speaker

GREEN CHEESE IT'S NOT!

COINCIDENCES involving the moon defy all rules of statistics. The Moon just happens to rotate on its axis in the same length of time it revolves about the Earth, on a parallel axis and in the same direction. In doing so, it perpetually and proudly displays one pock-marked face to us while modestly hiding its back side. Its period of revolution equals that of the human female's menstrual cycle on Earth. It subtends an angle at our eye (31") almost exactly equal to that of the Sun (32") to provide us observers with a ready-made occulter during solar eclipses. Its mass and distance from Earth are just right to pull tides, circulate our waters and clear our beaches of debris yet not so large as to wreak destruction. It conveniently foregoes a magnetic field of its own which would otherwise render Earthly compasses inoperable.

But where and when did this strangely beautiful satellite originate? For centuries fascination with the Moon has prompted heated arguments among scientists regarding its origin. Was it torn from the spinning Earth while the Earth was still molten or even after it solidified? Was it captured by the gravitational field of the Earth when it strayed too close? Did it grow by accretion, particles of primordial matter all condensing for some unknown reason in one place? Or is the Moon a twin but undeveloped sister of the Earth, their births coinciding?

The analysis of Moon rocks and regolith (the overlying "soil" which may or may not represent the mantle rock below) is now supplying clues to these long-pondered mysteries as multi-discipline teams of geologists, physicists, biologists and chemists evaluate and coordinate the vast amount of data being compiled from samples brought by the astronaut crews of Apollo 11 and 12. One decisive question has already been answered: It is possible to place scientific instruments including telescopes on the Moon. As the cosmological knots are painstakingly disentangled, we can expect, in the not-too-distant-future, manned lunar-based instruments to perform studies of more distant celestial bodies with far better resolution, clarity and sensitivity as well as far less interference than can be achieved from the best earth-restricted or earth-orbiting instruments.

Long before the first Moon samples were brought to Earth, a group of scientists was called together to decide on how the samples would be distributed, what kind of analyses would be conducted and who would conduct the analyses. Based on their recommendations, about 160 analysts—specialists in many disciplines—were designated PI's (principal investigators). They were polled to determine what form of sample they would need, the very minimum they could work with, what precautions would be necessary in preparing and shipping the sample. The curator's office

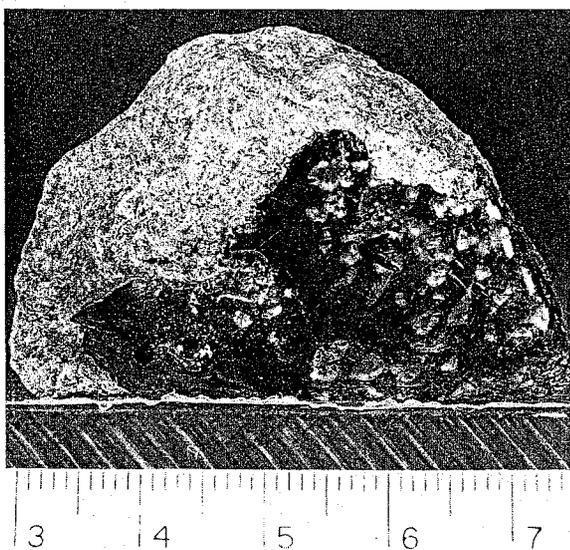


Fig. 1. Moon rock 12017 (17th from Apollo 12 mission) has been given a good deal of attention because of the glassy surface shown near the bottom of the rock in these photos taken before and after it was sliced for distribution. It is presumed that this glassy surface was the original top (designated T). Designations of the compass directions are arbitrary, no attempt by the astronauts having been made to record their orientation before they were picked up.

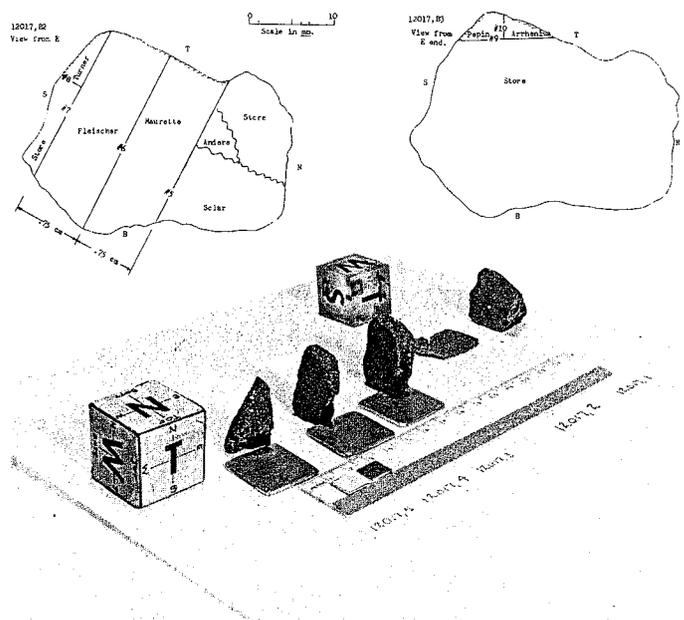


Fig. 2. Cut along the designated lines, portions of Moon rock 12017 were sent to the PI's (principal investigators) whose names are shown, the remainder stored in a vault at NASA's Manned Space Center under sterile nitrogen.

was then responsible for accommodating them. One scientist, incidentally, was disappointed. When no carbon was found in any of the samples, the scientist, whose specialty is the study of diamonds, was not sent a sample.

Figures 1 and 2 show the detailed care taken to record a sample and its disposition. Every scrap of unused sample, as is or in solution, is returned to the curator.

Certain tests had to be performed immediately, particularly radiation measurements. Half-lives of some of the nuclides are so short that even a day's delay can ruin the accuracy of measurements. For this reason, gamma ray spectrometers were placed aboard the recovery ship. More extensive measurements were later conducted at the Lunar Receiving Laboratory's elaborate sub-basement facility.

Other tests required that the sample be prepared in a certain form. For example, most of the chemical analysts wanted pulverized material representative of the bulk rock. To prepare such samples, a Spex 5100 Mixer/Mill with a 3118 agate grinding vial was chosen, agate having been found by others (1) to be best suited for grinding rocks without contamination. Samples were loaded into super-clean Spex polystyrene vials, the vials having first been blown out with dry nitrogen and individually examined for any particulates.

SAFETY of the Earth and its inhabitants, animal and plant alike, demand that extreme precautions be taken in handling any extraterrestrial materials. First and foremost must be the consideration of contamination and contagion. For, remote as it is, even the barest possibility that organisms exist on the Moon is enough to drive apprehensive chills up the backs of responsible scientists. Whether living, hibernating or suspended in animation as spores or seeds, any organisms released from the hostile environment of the Moon to the comparative lush one here on Earth could proliferate with catastrophic consequences.

To prevent such a disaster, all Apollo 11 and 12 samples were subjected to rigorous quarantine procedures at the Lunar Receiving Laboratory, NASA, Houston. From the time they were sealed in their naturally evacuated containers to when they were finally permitted to be opened to the normal atmosphere here on Earth, they were scrutinized by every conceivable test to determine whether there was any indication of life in any form. By helicopter, airplane and finally truck, the samples arrived at LRL to be transferred through an elaborate series of air locks into a chamber kept under high vacuum. There the first series of tests were begun: microscopic examination of the samples before and after being placed in nutrient broths to encourage growth. Samples of Moon rocks and soil were then transferred to chambers at a pressure kept just under ambient where still further tests were conducted. In special glove boxes, rocks were moved in with animals, cold and warm blooded. Scientists breathed easier when, 30 days later, reptiles, fish, amphibians, mice and rabbits showed no differences in behavior as compared with their controls over the 30-day isolation period.

When similar tests were performed with plants of various types one indication appeared to be positive. A fern and a moss responded to sprinkled Moon soil by growing 2-3 times faster than their controls in the same chamber. Further, they appeared greener and healthier. Was this evidence of an unknown nutrient, possibly alive, in the Moon dust? Would all further tests have to be postponed until the causative element was identified and its possible impact elsewhere on Earth predicted? Luckily, the effect turned out to be a false alarm. Someone recalled an Earth analog, powdered pumice. Volcanic pumice often acts like

a good fertilizer, its minerals readily leached by water and available to the growing plant.

Not only were the Moon rocks and regolith isolated during the quarantine period but anyone who came into contact with the material was similarly isolated. LRL contains living quarters for the returning astronauts and everyone from doctor to cook who backs them up. Complete kitchen facilities, dormitories and recreational areas are maintained in this isolated section, each of the rooms kept at reduced atmospheric pressure, a monitoring meter outside of each doorway on guard for a pressure increase.

The application of differential atmospheric pressure as a means of preventing mishaps deserves particular emphasis. The principle is to contain any spillage by air movement. Should a room seal break, outside air pressure would rush in its direction to confine any organisms. Meanwhile, an alarm would sound to alert the safety technicians to the problem. One accident did actually occur, fortunately with little damage. A Moon sample was being manipulated in an evacuated glove box by a man wearing not the usual rubber gloves but special metal-sheathed gloves designed to withstand the pressure differential. Suddenly, a glove broke, seizing the man's arm, breaking some capillaries and eventually turning the arm black and blue. Because the man and others in the room had been subjected to "emanations" from the Moon rock, they were unceremoniously sealed in the newly quarantined room.

The system of pressure differentials is bewilderingly elaborate at LRL. As many as four pressure tiers are maintained depending on the particular problem. The main office area is kept at ambient pressure, the isolated rooms at about 0.1 foot of water pressure below this and the glove boxes at still another 0.1 foot of water below this. A fourth tier had to be established for a group of delicate mice which had trouble surviving in the low pressure of the glove boxes. To accommodate them, they were placed in a box within the glove box. Their box was kept at ambient pressure.

Thus far absolutely no evidence of life has been found on the Moon. Except for the surfaces of samples which have been shown to contain a layer of carbon deposited by solar wind, carbon—the one element common to all life—has not been detected. Core samples, surface dust and several types of Moon rocks from two areas separated by hundreds of miles have now been investigated with that invariant conclusion, a conclusion that permits relaxation in handling of future samples. Instead of being quarantined in a vacuum environment, samples from Apollo 14 will be taken directly to the low pressure areas.

So much for the precautions. What happens to the samples after they are given a clear bill of health? At the outset it was recognized that Moon samples deserve to be treated like the most precious museum pieces, entrusted to a curator responsible for their temporary disposition, return and long-term storage. When not out for experiments, all samples are thus kept in sterile, nitrogen-purged vaults. This precaution is taken because twenty years hence tests may be devised for examining the rocks for some unusual property; it would be senseless to run the risk of any kind of foreseeable contamination. As this article is being written, reports about carbonaceous materials being detected in a meteorite found here on Earth are being published. The meteorite is fresh and chances of contamination from handling are presumably minimal. Curators at NASA's Houston Manned Space Center are to be commended for their insistence that Moon samples be preserved without danger of any kind of contamination.

THE emission spectrograph and a combustion analyzer are considered primary analytical tools, the former because of its unrivalled ability to survey a sample for 70-odd elements ranging from the ppm range upward, the latter because of the importance of carbon as an indicator of life. Accordingly, both instruments were located inside the low-pressure quarantine area where they could be put to work soon after the samples were documented.

Because the spectrograph vaporizes samples, scientists were concerned over the possibility of escaping material. To overcome this and at the same time provide an atmosphere optimum for the analysis, the arc stand of the spectrograph was placed in a glove box fed with a mixture of 20% oxygen, 80% argon. The absence of nitrogen permits the determination of those elements whose spectral lines fall in the broad cyanogen band regions.

The spectrographic results obtained at LRL were expected to be merely preliminary; qualitative figures within a factor of around 5 of the amounts actually present were all that were desired. These would serve merely as a guide to the subsequent work of the PI's with the time, sophisticated equipment and methodology for more quantitative analyses. As it turned out, however, the preliminary method chosen by LRL spectrochemists yielded excellent semi-quantitative figures, close to the averages reported later by a variety of techniques.

Secreted in a literature haystack with many other excellent technical articles, the spectrographic technique was developed by W. H. Dennen and published as his PhD thesis in MIT's Geology Department. Equal parts of the sample (5 mg is a typical allotment of the precious material) and SrCO_3 , doped with Pd as an internal standard are mixed with 4 parts of high-purity graphite powder. Weighed triplicate samples are transferred to a National L-4258 preformed electrode (a micro crater machined atop a $\frac{1}{4}$ " ϕ pedestal) and the sample burned to completion in a dc arc at 8 amp. The argon atmosphere provides its own end point, the arc suddenly turning green when the sample has completely volatilized. As standards for the common major elements of interest (Si, Al, Fe, Ti, Mg, Ca, etc.), high-purity compounds were blended with SrCO_3 and graphite. For the noble metals and rare earths, appropriate Spex Mixes constituted the base materials for the standards. Spectrum Analysis #3 emulsion was selected for the photographic record in order to provide an extended wavelength as well as concentration range.*

As in a rapidly growing number of other spectrographic labs, a computer at NASA has taken much of the horse-work out of the struggle to convert microphotometer readings of spectral lines into % concentration. At present, peak density values are manually fed to the computer which, programmed to interpolate the data from analytical curves plotted with the standards, neatly responds by furnishing the appropriate concentration. The computer averages the data from three replicate burnings, and types out a neat report, identifying the sample, date of the analysis, etc. Personnel in the laboratory are currently planning to ease their job still further. By modifying their microphotometer so it can record peak density values, they will be able to transfer these figures directly into the input of the computer.

*The author discussed with Pratt H. Johnson, J. Roger Martin and W. B. Nance the advantages of Kodak's 33 emulsion over SA#3. Almost identical in its characteristics with SA#3, 33 exhibits an improved rms granularity, about twice as good as that of SA#3. Theoretically — and practically as a number of other spectrochemists have demonstrated to their satisfaction — this improves the limit of detection by an equal factor.

X-ray spectrochemical analyses augment those of the emission spectrograph for more quantitative determinations especially of major elements. Here a somewhat unorthodox fluxing agent was favored as a means of outwitting the matrix which varies from one sample to the next. The flux consists of a mixture of lithium tetraborate, lithium carbonate and sodium nitrate which, in turn, is mixed with 100 mg of the sample in a 5:1 ratio after the work of Norris and Hutton (2). The method has proved to be outstanding in both accuracy and sensitivity. Most elements are determined down to 0.1% routinely; potassium, an element important for its dating implications, is determined down to 0.01%.

Electron probe analyses have supplied most of the data for mineral identification and it was most enlightening to learn the extent this new tool has progressed in but a few years. Sample preparation, once demanding a degree of patience and manual dexterity not characteristic of many enthusiastic scientists, is now quite straightforward. A sliver of the rock around 30 microns thick is first cut with a diamond saw and cemented to a glass slide with epoxy resin. The surface of the section is next polished to a high luster. Finally, a conducting coating of carbon is evaporated on the surface.

That the electron probe could detect and measure the intensity of characteristic x-ray lines from a large number of elements had been demonstrated several years back. That the probe was capable of a spatial resolution in the order of 5 microns or less had also been demonstrated. Quantitative determinations were another story, however. How does one relate the intensity of a particular line to its concentration in that matrix? A reliance on synthetic macro standards is dangerous because of the real danger of micro segregation. Natural standards — mineral samples known to be fairly homogeneous — proved somewhat better but limited in number and kind. Fortunately, John Rutledge of the University of Toronto had devised a computer program based on theoretical considerations. Taking into account all of the known influences on intensity of lines — the area under the intensity curve, the absorption of x-rays by other elements in the sample and the atomic number — he arrived at a complex computer program which has served as the basis of most quantitative geological analysis with the electron probe. The close-knit community of about 30 geochemists who work with the electron probe cooperatively exchange samples and standards and constantly upgrade the Rutledge program; high accuracy is now routinely achieved.

The electron probe suffers from two shortcomings which promise to be overcome by the ion probe already on order by NASA scientists in Houston. Although the sensitivity of the electron probe is phenomenal in terms of the total number of grams of an element detected, in terms of the concentration of that element it is not so remarkable. Generally speaking the electron probe is limited to major elements, the concentration of which is several percent and greater. Its other shortcoming is an inability to distinguish between isotopes of the same element. Certain isotopes constitute the end products of radioactive decay, and knowledge about their concentration is therefore essential for dating work. The ion probe promises to overcome both of these limitations. When a sample is bombarded with a finely focused beam of ions, atoms are knocked out. These are then ionized and analyzed by means of a self-contained mass spectrometer.

In this survey of principal instrumental techniques encompassed at NASA's Houston facility, conventional mass spectroscopy should not be overlooked. The search for organic fragments and carbon has been carried out mainly through this powerful analytical tool. Its threshold of sensitivity for organic compounds is a remarkable 10 ppb and although some determinations appear to detect organic compounds around this level, they could easily have been the result of contamination either in the laboratory or from the exhaust of the lunar module. Gas analysis has also been carried out with the mass spectrometer and easily measurable quantities of hydrogen, helium and other elements have been unquestionably found. By taking samples from the surface and working progressively toward the center of the rocks, mass spectroscopists have shown a steady decrease in concentration of these elements with depth. In fact, they can often tell which rock surface was facing up; it exhibits the highest concentration of elements carried and deposited by the solar wind. Put another way, this was one of the means of verifying the existence of the solar wind, which, until actual analyses were conducted, was only theorized.

Gamma ray spectrometry is carried out at Houston in a specially constructed room buried 15 meters underground. Elaborate precautions have been taken to bring the natural background of radioactivity down. Radon-free air is circulated. The room is shielded with a 3-foot-thick wall of compacted dunite (a pulverized igneous rock). Outside of this is a wall of welded steel selected for its low radioactivity. To prevent interference from cosmic rays, anti-coincidence counters are appropriately arranged. An inner mantle of lead reduces the background still further.

Nuclide determinations by gamma ray spectrometry are essential not only for dating the rocks but also for characterizing the Moon's environment. For example ^{26}Al has been found to be quite high in Moon rocks. This can be explained by postulating that the Moon has been exposed to cosmic-ray bombardment for a time long enough to result in saturation, a period calculated to be several half-lives, i.e., several million years.

THE single outstanding characteristic of the materials thus far collected in both the Apollo 11 and 12 missions is their non-earthly composition. Without exception they all contain a lower ratio of volatile to non-volatile elements. For example, the K/U ratio of Moon samples averages around 2500; of Earth rocks, around 10,000; of chondrites (stony meteorites) around 85,000. Even more striking, the ratio K/Ba in the Earth's crust hovers around 300 but is only about 8 in Moon samples. And very volatile metals — Pb, Cd and As — are practically depleted in Moon samples although they occur as traces in almost all Earth samples.

These data on the relative lack of abundance of volatile elements constitute evidence that the Moon samples were hotter at one time in their history than either the Earth's mantle or chondrites.

The absence of water-transported sediments or any significant amounts of hydrated minerals in the Moon samples indicates that there was very little water on the Moon at the time these rocks crystallized. This is another feature distinguishing the Moon's crust from that of the Earth or other planets which, through infrared absorption measurements, are known to contain atmospheric water vapor.

Europium is turning out to be yet another tracer element for studying Moon rocks through an effect known as

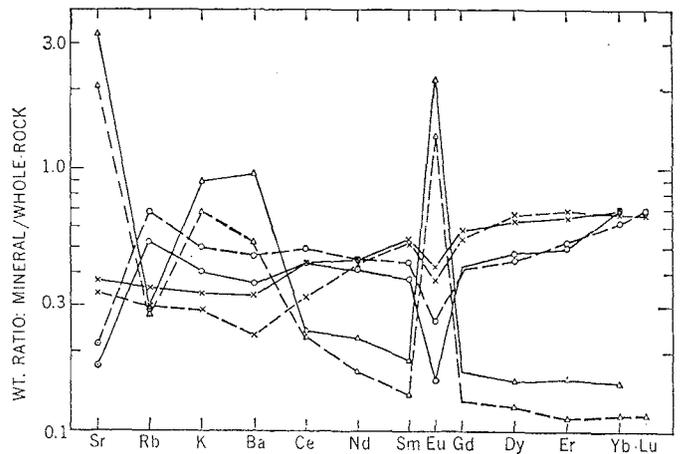


Fig. 3. Europium anomaly as depicted in the analysis of eight different rocks from Apollo 11. In neither Earth nor Moon rocks does Eu fall in line with other rare earths when plotted relative to their atomic number. Departure from a straight line, however, is much more pronounced in the Moon samples (3).

the "Europium Anomaly," first discovered in terrestrial rocks (Fig. 3). Rare earths are almost identical in their physical and chemical properties, the reason, of course, that they are so hard to separate. For the same reason, when rare earths appear in certain terrestrial minerals their relative abundance is practically constant. Only one exception has been found, europium. Of all of the rare earths, only europium forms the stable divalent ion in nature. Under the reducing conditions prevailing when the Earth was still molten, Eu^{3+} was partially reduced to Eu^{2+} . Minerals of univalent metals, such as potassium feldspars, exhibit an affinity for Eu^{2+} , soaking it up and thus fractionally crystallizing it. Molten basalt, on the other hand, does not show this affinity for Eu^{2+} . The result is that the relative abundance of europium to the remaining rare earths is greater in feldspars than in most other igneous rocks.

Now when the Moon first solidified, it presumably was exposed to less oxygen than was the Earth. Reducing conditions were thus accentuated, a greater percentage of europium reduced to Eu^{2+} . Accordingly, partitioning proceeded to a greater extent and lunar feldspar contains whopping concentrations of europium. Lunar basalts, on the other hand, show some depletion of europium relative to the other rare earths (3).

Of the rocks thus far collected, 12013 is unique, (Fig. 4) an entire issue of *Earth and Planetary Science Letters* having been devoted to its characterization and speculation regarding its origin. The rock was found by one of the astronauts who spotted its whitish appearance glinting against the greyish-black moonscape. Its discovery, incidentally, points up one of the powerful advantages of human exploration. Discovery of 12013 by a robot would have been highly unlikely. Half-a-thumb in size, it would probably have remained unnoticed except by a human being right there at the site.

Unlike most of the other Moon rocks, 12013 is an aggregate, a breccia of many different fragments cemented together in a complex, disordered manner. On a gross scale, it contains 61% SiO_2 , three times higher than any other Moon rock. Its concentrations of K, Rb, Ba, Zr, Y, Yb and Li are enriched 10-50 times over other Moon rocks. The high silica is reminiscent of granite on Earth. Granite,



Fig. 4. Moon rock 12013, weight 82 g, largely composed of turbid white crystals. Some darker minerals are present in segregated patches; several highly reflective opaque crystals may prove to be ilmenite.

comprising the major rock formations of our continents, is mostly sedimentary in origin. Basalt, on the other hand, with its high iron and magnesium, results from lava flows and is found on the ocean floor and at the bottom of places like Grand Canyon.

Several different dating methods were applied to 12013 as an aggregate. They show that the rock in its present state was formed 4.0 billion years ago. When individual components were removed and dated, however, granitic fragments were found to date back more than 4.5 billion years. The oldest components were found to be basaltic in composition. This indicates that stony granitic material existed on the Moon very early in its history. A lava flow of still earlier basaltic material picked up these granitic fragments, remelted them 4.0 billion years ago.

Where did 12013 come from? It could have been blown from the highlands by the impact of a meteor. If so, exploration of nearby highlands should reveal many more similar rocks. In fact, the ill-fated Apollo 13 mission was supposed to have landed its craft in just such a place, geologists speculating that the highlands contain material from deep inside the Moon.

Another question relates to the remelting process itself. Where did the heat come from to melt 12013 a second time? The explosion of a meteorite is one possibility. Another is internal radioactivity. The source and history of 12013 will remain a mystery until much more exploration of the Moon is conducted.

Stock market analysts neatly side step firm predictions, cloaking them with generous sprinkles of semantic "ifs"

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and "buts." Astronomers, archeologists and geologists are equally difficult to pin down. The only difference is that they deal with the distant past, the stock market pundits, with the near future. The hesitancy of the scientists however, is understandable. Before rocket research was begun in earnest, they were equally divided between those who believed that the Earth and Moon shared a common origin and those who believed, with equally convincing arguments to back them up, that the two bodies were entirely unrelated.

The data collected thus far tend to support the latter faction. Compositional differences have already been cited. Age measurements through dating of rocks substantiate these findings. Both composition and dating of Moon samples offer the best evidence, albeit circumstantial, that the Moon and Earth were never united. Yet, it must be remembered that all dating techniques assume a homogeneous sample, one which gives rise to a measurement represented by a single event, one in which every fragment in the bulk rock solidified at the same time. Also made is the assumption that the rock solidified but once; in other words, the date of origin could, conceivably, be prior to that measured if the rock melted and resolidified at a later date.

Granting these assumptions, Moon rocks have been found to vary in age from 3.5 to 4.5 billion years. By contrast, the oldest basaltic rocks on Earth are probably no more than 3.8 billion years old. Incidentally, the solar system is thought to be 4.8 billion years old.

Apart from compositional and dating differences, implications can be drawn from a number of physical measurements that the Moon and Earth are not sisters. The Moon's lack of magnetic field is probably caused by the fact that, unlike the Earth, it contains no iron core. Its moment of inertia is that of a solid body without the molten interior the Earth is thought to slosh about. Its average density is significantly lower than that of Earth, 3.34 vs. 5.52 g/ml. Calculations indicate that its size is too big for it to have been whirled free of the Earth when it was completely molten.

So the enigma deepens. Like any other mystery story, the first pieces of evidence to accumulate tend to add to the confusion—not clarify matters. Someday—within our lifetime, we hope—they will be fitted together into a unified origin theory. Exploration of the Moon and later of the closest planets will hasten that important day to Man the Curious.

ESPECIALLY, do I wish to thank James E. Townsend, former spectrochemist now assistant curator, for his kind help in directing me to the myriad laboratories and scientists responsible for the continuing thorough evaluation of Moon samples.

—AJM

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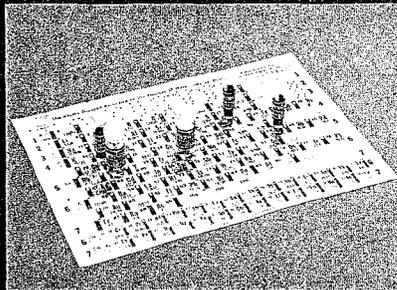
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2. Norris and Hutton, *Geo. and Geoch. Acta*, **33**, 431, 1969.
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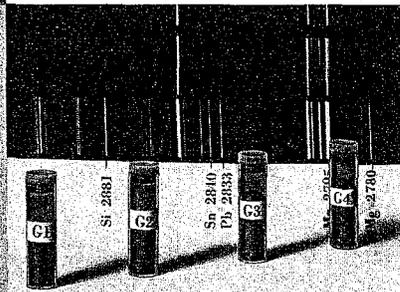
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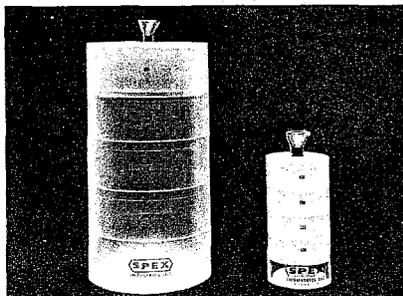
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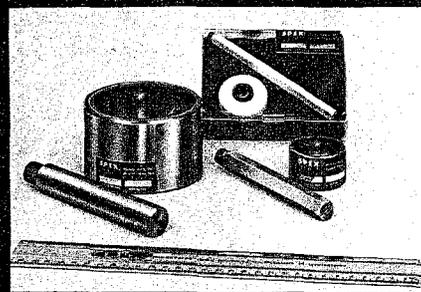
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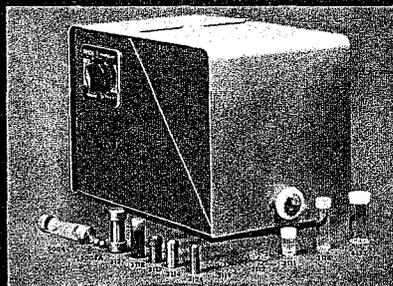
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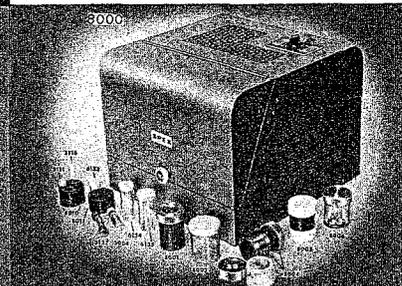
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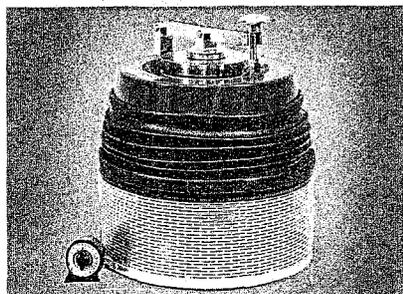
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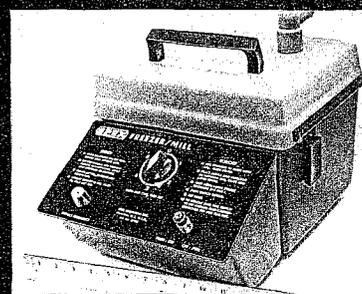
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Al	(.001)	(.0025)	(.007)
Cu	.05	.10	.25
Ag	.019	.036	.049
Cd	.0057	.010	.025
Zn	(.0005)	(.0013)	(.003)
Au	.04	.10	.25
Sn*	63.0	63.2	63.5
Pb	Balance	Balance	Balance

() — Subject to segregation effects. Not intended for calibration purposes.

* — Tin values are listed for the purpose of alloy identification only.

Tin/Lead Solder

	Sn	Sb	Cu	Au	Price
S.S.C.A. #1	59.08	.12	<.0001 ND	(.10) (.01)	\$25.00
S.S.C.A. #2	60.05	.30	.053	(.01)	\$25.00
S.S.C.A. #3	61.19	.50	.10	.040	\$25.00
S.S.C.A. #4	62.36	.13	.25	.10	\$25.00
S.S.C.A. #5	63.08	.30	.42	.25	\$25.00
S.S.C.A. #6	64.72	.49	.51	.50	\$25.00

() — Not for calibration purposes.

Federal Composition Sn 40 — ASTM Alloy Grade 40A, 40B (Final certification pending) set of 3 \$85.00

	Pb	Sn	Sb	Bi	Cu	Ni	Ag	As
TL-1X	Rem.	40.00	.15	.03	.005	.005	.005	.007
TL-2X	Rem.	39.30	.43	.06	.011	.012	.01	.01
TL-3X	Rem.	39.70	.75	.15	.04	.03	.025	.03

Tin—Impure (Final certification pending)

set of 3 **\$75.00**

	Sn	Sb	As	Bi	Pb
TX-1	Rem.	.01	.01	.01	.05
TX-2	Rem.	.05	.05	.05	.10
TX-3	Rem.	.10	.10	.10	.30

Federal Alloy Composition Sn 62

set of 3 **\$85.00**

	Sn	Pb	Ag	Bi	Cu	Sb	As	Zn
TLS-36X	59.88	Rem.	2.99	.048	.073	.51	—	—
TLS-37X	61.85	Rem.	2.02	.093	.040	.38	—	—
TLS-38X	63.60	Rem.	1.02	.25	.010	.23	—	—

Federal Alloy Composition Sn 10

set of 3 **\$85.00**

	Sn	Pb	Ag	Bi	Cu	Sb	As	Zn
LTS-33X	8.88	Rem.	2.86	.0072	.073	.21	—	—
LTS-34X	10.09	Rem.	2.10	.012	.042	.09	—	—
LTS-35X	11.10	Rem.	1.06	.035	.0089	.05	—	—

Federal Alloy Composition Ag 1.5 — ASTM Alloy Grade 1.5 S

set of 3 **\$85.00**

	Sn	Pb	Ag	Bi	Cu	Sb	As	Zn
LST-30X	.41	Rem.	1.86	.055	.23	.42	(.005)	(.001)
LST-31X	.97	Rem.	1.48	.10	.14	.25	(.01)	(.0025)
LST-32X	1.40	Rem.	.49	.27	.068	.11	(.02)	(.005)

() — Percentages listed are intended values only. Final certification pending.

Federal Alloy Composition Sb 5*

set of 3 **\$85.00**

	Sn	Sb	As	Bi	Pb	Cu	Zn	Cd	Fe
TA-4X	Rem.	4.0	.03	.10	.10	.04	.015	.015	.04
TA-5X	Rem.	5.0	.02	.005	.025	.003	<.0005	<.005	.004
TA-6X	Rem.	6.0	.05	.25	.20	.08	.03	.03	.08

Federal Alloy Composition Sn 96*

set of 3 **\$85.00**

	Sn	Sb	As	Bi	Pb	Cu	Zn	Ag
TS-3X	Rem.	.20	.01	.05	.02	.20	.001	3.0
TS-4X	Rem.	.10	.02	.10	.05	.10	.0025	4.0
TS-5X	Rem.	.05	.05	.25	.10	.03	.005	5.0

* — Final certification pending.

Tin with Antimony

	Sn	Sb	Price
TA-1	Remainder	1.03	\$25.00
TA-2	Remainder	2.01	\$25.00
TA-3	Remainder	3.05	\$25.00
TA-5	Remainder	5.09	\$25.00
TA-8	Remainder	8.02	\$25.00
TA-10	Remainder	10.09	\$25.00
TA-12	Remainder	12.42	\$25.00

High Purity Low Tin Solder, made from 99.999 pure tin and lead.

May be used in melting point studies.

	Sn	Pb	Price
TL-3	2.95	Remainder	\$30.00
TL-7	6.77	Remainder	\$30.00
TL-10	9.78	Remainder	\$30.00
TL-12	12.02	Remainder	\$30.00
TL-15	15.19	Remainder	\$30.00

Federal Alloy Composition Ag 2.5 — ASTM Alloy Grade 2.5 S*

set of 3 **\$85.00**

	Sb	Pb	Ag	Bi	Cu	As	Sn	Zn
LS-1.5X	.40	Rem.	1.5	.05	.30	.005	.05	.001
LS-2.5X	.25	Rem.	2.5	.10	.15	.01	.10	.0025
LS-3.5X	.10	Rem.	3.5	.25	.08	.02	.25	.005

Federal Alloy Composition Ag 5.5*

set of 3 **\$85.00**

	Sb	Pb	Ag	Bi	Cu	As	Sn	Zn
LS-4.5X	.40	Rem.	4.5	.05	.30	.005	.05	.001
LS-5.5X	.25	Rem.	5.5	.10	.15	.01	.10	.0025
LS-6.5X	.10	Rem.	6.5	.25	.08	.02	.25	.005

* — Final certification pending.

Babbitt Metal

Each **\$30.00**

	Sb	Pb	As	Sn
BM-1	13.96	Remainder	.94	.97

BUREAU OF ANALYSED SAMPLES STANDARDS

LOW ALLOY STEELS

GROUP 'A'

S.S. No. 1½ in. dia. discs	C %	Si %	S %	P %	Mn %	Ni %	Cr %	Mo %	V %	Cu %
401	1.06	0.59	0.009	0.042	1.00	0.02 _s	0.08 _o	0.52	0.52	0.10 _o
402	1.29-	0.27	0.023	0.006	0.19	0.73	0.55	0.16	0.22	0.23-
403	0.72-	0.08 _o	0.036	0.064	1.69	0.24	0.42	0.08 _o	0.24	0.17-
404	0.67-	1.04	0.018	0.050	0.52	0.46	0.68	0.33	0.10 _o	0.30-
405	0.058	1.38	0.060	0.017	1.28	0.12	0.21	0.017	0.32	0.015

GROUP 'B'

S.S. No. 1½ in. dia. discs	C %	Si %	S %	P %	Mn %	Ni %	Cr %	Mo %	V %	Cu %
406	0.19 _o	0.38	0.049	0.014	0.53	1.69	2.12	1.03	0.020	0.32
407	0.50	0.69	0.012	0.033	0.13	0.61	3.00	0.82	0.23-	0.43
408	0.28	0.24	0.030	0.043	0.64	4.58	0.09 _o	0.14	0.063	0.73
409	0.11 _o	1.07	0.015	0.025	0.48	3.14	1.22	0.77	0.028	0.23
410	0.39	1.00	0.053	0.066	0.43	2.04	1.72	0.41	0.46-	0.47

LOW TUNGSTEN STEELS

S.S. No. (1½ in. dia. discs)	W %	C %	Si %	S %	P %	Mn %	Ni %	Cr %	Mo %	Cu %
421	0.52	0.05	0.07	0.027	0.012	0.11	...	...	0.03	...
422	1.27	0.04	0.06	0.025	0.015	0.09	...	...	0.03	...
423	2.06	0.03	0.05	0.027	0.017	0.07	...	...	0.03	...
424	3.02	0.02	0.05	0.024	0.018	0.09	...	...	0.04	...

NICKEL-BASE ALLOYS

S.S. No.	Disc diameter	Cr %	Co %	Ti %	Al %	C %	Mn %	Si %	Fe %	Ni %	Cu %	S %
363	1½ in.	...	0.19	...	0.005	0.11	1.03	0.05 _s	1.70	63.8	32.93	0.010
310/1	1⅞ in.	19.4 _s	17.0-	2.43	1.06	0.068	0.35	0.46	0.25	58.6	...	...

ALUMINIUM-SILICON ALLOYS

S.S. No. (2½ in. dia. discs)	Cu %	Mg %	Si %	Fe %	Mn %	Ni %	Zn %	Pb %	Sn %	Ti %
501	0.20	0.52	8.8	0.72	0.12	0.24	0.02	0.22	0.12	0.18
502	0.43	0.66	10.0	0.19	0.60	0.07	0.24	0.17	0.25	0.10
503	0.10	0.32	11.3	0.11	0.70	0.31	0.17	0.14	0.07	0.13
504	0.29	0.22	12.0	0.52	0.30	0.02	0.06	0.07	0.03	0.17
505	0.04	0.06	12.8	0.36	0.51	0.20	0.25	0.09	0.16	0.03
506	0.02	0.12	13.5	0.41	0.20	0.14	0.30	0.02	0.15	0.07

ANTI-HALATION BACKING ON FILM

Like most other spectroscopists, we suspect, we have always been mystified by the Remjet black anti-halation backing with which Eastman Kodak coats its spectroscopic films. Demanding an extra processing step (weak sodium carbonate solution) for its removal, the backing appears to be purposeless. As if to demonstrate its concurrence, the manufacturer occasionally produces films without the backing. A little detective work prompted by an inquisitive researcher seems to have cleared up the mystery.

Most 35-mm film is sold by Kodak for motion picture cameras. Some winds up in high-speed cameras. Here, particularly in wintertime, electrostatic charges can build up as the film is rapidly unspooled, charges which discharge and are developed as miniature lightning bolts. Electrically conductive, the Remjet backing prevents charges from building up.

Correctly reasoning that some users would benefit by the Remjet backing and none would suffer unduly, Kodak personnel decided to supply the backing to all unless otherwise specified.

From now on, Spex stock will be otherwise specified, i.e., unbacked. It is coded CB (clear backing) instead of JB in the batch number. If you wish the Remjet backing you will need to request a special order.

NEW SPECTROCHEMICAL STANDARDS

Standards are the backbone of all instrumental methods of analysis, the immutable points of reference from which all quantitative information derives. It is not, therefore, surprising that, along with the constant effort by alloy producers to narrow their specifications and the equally constant announcements of new specialty alloys, a corresponding number of new standards are needed.

Spex is adding several to its extensive library of standards, one, a group prepared by a well known practicing spectrochemist, G. R. Brammer. These standards have been widely tested by a cross-section of analysts using wet, x-ray and emission techniques.

At the same time, we are pleased to announce a number of new British Bureau of Analysed Samples standards. These are considered primary standards, each one accompanied by a certificate in which raw data from the participating laboratories are presented as well as the accepted, weighted-average values.

Cat. No.	Price
BSS 401-405	Set of 5 \$ 94.00
BSS 406-410	Set of 5 \$ 94.00
BSS 412-424	Set of 4 \$ 68.00
BSS 363	Monel Alloy 400 \$ 18.50
BSS 310/1	Nimonic Alloy 90 \$120.00
BSS 501-506	Set of 6 \$192.00
All Brammer Standards	Each \$ 25.00

We are soliciting orders for Brammer ferrous standards not included among those listed here as well as non-ferrous standards to be made by Alpha Metals, Inc. Alpha, a well known producer of specialty alloys for the electronics industry, is offering to supply sets of standards of alloys of lead, tin, indium, silver and gold.

Please tell us of your needs for these ferrous or non-ferrous based standards. Naturally, a high minimum charge would be made should only a single organization be interested in a special alloy. On the other hand, this charge could easily be prorated among a number of organizations. Chances are that, through the wide distribution of this SPEAKER issue, enough requests for a particular type of standard will be received to make its production feasible. Please direct your requests to L. S. Casper, sales manager of Spex Industries, Inc., who will be correlating them.

BRAMMER STANDARDS ANALYTICAL DATA

STANDARD NO.	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al*	Nb	V	Co	Ta	φ"	thick
CARBON STEEL																	
BS 1023 (57 B)	.24	.45	.007	.024	.062	.011	.028	0.33	.007	.003	.004	—	—	—	—	1 3/4	3/4
BS 1020 (57 D)	.22	.525	.006	.018	.048	.025	.015	.020	.004	.002	.004	—	—	—	—	1 3/4	3/4
BS 1045 (56 D)	.45	.78	.019	.044	.21	.023	.017	.054	.005	.003	.024	—	—	—	—	1 3/4	3/4
BS 1045 A	.47	.85	.011	.028	.110	.064	.027	.020	.008	.005	.008	—	—	—	—	1 3/4	3/4
LOW ALLOY																	
BS 4140	.41	.84	.015	.022	.26	.12	.22	.96	.17	.008	.019	—	.003	—	—	1 3/4	3/4
BS 4340	.39	.82	.015	.022	.25	.095	1.68	.90	.28	.007	.030	—	.005	—	—	1 3/4	3/4
BS 4615 (51 D)	.166	.57	.009	.015	.175	.16	1.73	.20	.23	.007	.022	—	—	—	—	1 3/4	3/4
BS 4620	.20	.56	.008	.022	.28	.10	1.87	.045	.25	.009	.042	—	—	—	—	1 3/4	3/4
BS 8620	.19	.74	.014	.031	.22	.08	.43	.48	.15	.008	.031	—	.002	—	—	1 3/4	3/4
BS 9310 (58 B)	.100	.54	.010	.011	.29	.070	3.25	1.25	.12	.007	.035	—	—	—	—	1 3/4	3/4
BS E52100 (53 C)	1.00	.36	.012	.010	.24	.125	.24	1.62	.032	.011	.003	—	.006	—	—	1 3/4	3/4
52 C	.44	1.12	.072	.092	.26	.06	.13	.08	.07	.005	.005	—	—	—	—	1 3/4	3/4
53 C	1.00	.36	.012	.010	.24	.125	.24	1.62	.032	.011	.003	—	—	—	—	1 3/4	3/4
54 B	.68	.89	.011	.062	.28	.16	.58	.53	.21	.011	.054	—	—	—	—	1 5/8	3/4
55 C	.35	.81	.015	.008	.62	.070	.11	1.75	.47	.006	.004	—	—	—	—	1 3/4	3/4
STAINLESS																	
BS 303	.080	1.75	.027	.33	.55	.19	8.08	17.20	.30	—	—	.003	.035	(.12)	—	1 3/4	1/2
BS 304	.066	1.39	.030	.029	.75	.24	9.15	18.46	.35	(.015)	—	.005	.045	(.20)	—	1 3/4	1/2
BS 316	.048	1.60	.023	.026	.57	.10	12.58	17.20	2.76	(.012)	.016	—	.067	.33	.022	1 3/4	1/2
BS 347	.074	1.60	.020	.006	.76	.15	9.80	17.40	.26	(.011)	.10	.66	.041	(.24)	.012	1 3/4	1/2
BS 410	.105	.46	.016	.015	.21	.067	.30	11.75	.077	(.005)	.005	—	.039	(.044)	—	1 3/4	1/2
BS 416	.102	.97	.022	.42	.38	.075	.23	13.40	.10	—	—	—	.025	(.027)	—	1 3/4	1/2
BS 430F	.030	.42	.011	.33	.45	.050	.24	17.75	.02	(.002)	.037	—	.037	(.030)	—	1 3/4	1/2
BS 440C	1.00	.50	.014	.023	.42	.060	.27	17.02	.49	(.007)	.006	.002	.061	(.045)	—	1 3/4	1/2
BS 17-48H (Armco)	.062	.55	.020	.011	.75	3.40	4.76	15.90	.23	(.011)	.019	.36	.030	(.058)	.020	1 3/4	1/2

*Note — All aluminum values by spectrochemical analysis only. Analyses in () are given for general information and are not certified.

NO BOXTOPS PLEASE!

Receipt of a letter from Australia a few weeks back coaxes us into announcing a fabulous, fantastic, fun-filled contest for all of you personable progress pursuers out there. Prizes galore that will be treasured, albeit temporarily, inside your cozy wallet!

This agronomist from Adelaide inquired about a Mixer/Mill as "used by Prof. Stolzy in root air space measurements by a pycnometer method (Agronomy Journal, **61**, 474, 1970)." Well isolated from the rich black loam of the American farm belt, we confess to a total ignorance of the implication of this application. Orders come, Mixer/Mills

go, what they do we rarely know!

But we aim to find out. Send us your unusual applications of our Mixer/Mills, Wig-L-Bug, Freezer/Mill or Shatterbox. For the most novel and innovative application we will award a Grand Prize of \$100; 25 runners-up will receive \$10 each.

Winners will be announced in the next issue of the SPEAKER together with a description of the techniques.

Opinions of our judges will be final. No entries will be returned. Just fill out the form below and fold into a window envelope or add further details on separate sheet.

Deadline March 1, 1971.

SPEX INDUSTRIES, INC.
Box 798
Metuchen, N.J. 08840

Attn: CONTEST PANEL

Gentlemen:

My entry is for grindingmixing

..... gram quantities of

(identify material)

We utilize the Spex #5100 Mixer/Mill.....; #8500 Shatterbox.....;

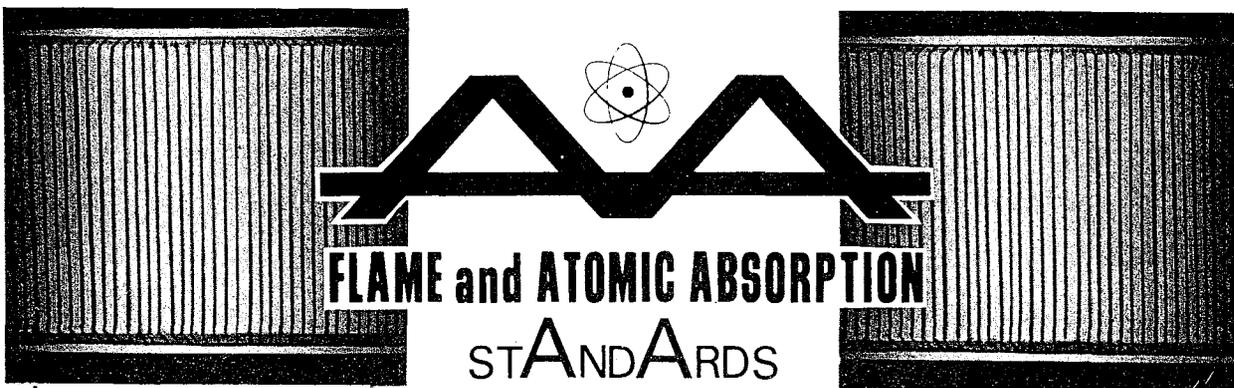
#8000 Mixer/Mill.....; Wig-L-Bug.....

#6700 Freezer/Mill.....; Vial or Grinding Dish:

The purpose of our operation is:

Further information is published in:

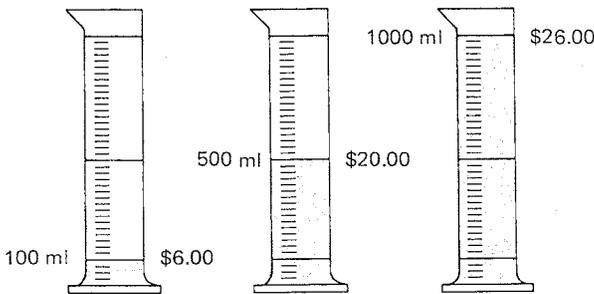
IF NECESSARY CORRECT THE NAME AND ADDRESS ON THE FLIP SIDE OF THIS FORM



FLAME and ATOMIC ABSORPTION STANDARDS

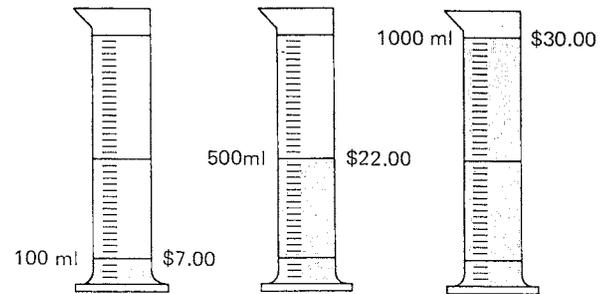
500 $\mu\text{g/ml}$ SOLUTIONS

Be Cd Li Mg Na Zn



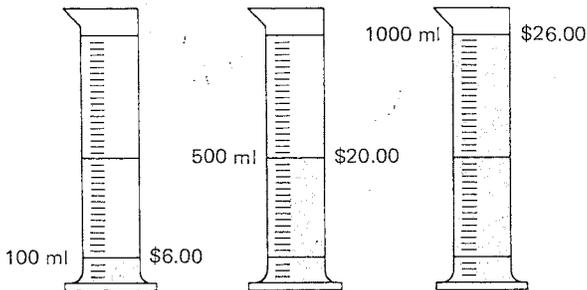
5000 $\mu\text{g/ml}$ SOLUTIONS

Al As Bi Dy Ge Ho Hg In Mo Se Sb Si Sn Te Ti Tl



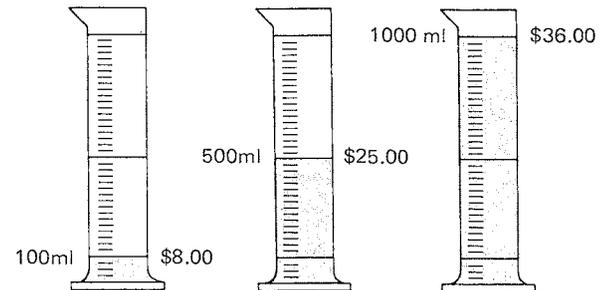
1000 $\mu\text{g/ml}$ SOLUTIONS

Ag Ba Ca Co Cr Cs Cu Fe-K Mn Ni Pb Rb Sr V



10000 $\mu\text{g/ml}$ SOLUTIONS

B Gd Hf La Nb Pr Sm Ta U W Zr



ADDITIONAL RARE EARTHS AND NOBLE METALS

ELEMENT	Concentration $\mu\text{g/ml}$	Price 100/ml	Price 500/ml	Price liter	ELEMENT	Concentration $\mu\text{g/ml}$	Price 100/ml	Price 500/ml	Price liter
Au	1000	\$9.00	\$26.00	\$38.00	Ru	5000	\$9.00	\$26.00	\$38.00
Rh	1000	9.00	26.00	38.00	Sc	5000	10.00	40.00	66.00
Yb	1000	9.00	26.00	38.00	Tm	5000	10.00	40.00	66.00
Er	5000	9.00	26.00	38.00	Nd	10000	10.00	40.00	66.00
Eu	5000	9.00	26.00	38.00	Re	10000	10.00	40.00	66.00
Ga	5000	9.00	26.00	38.00	Tb	10000	10.00	40.00	66.00
Pd	5000	9.00	26.00	38.00	Y	10000	10.00	40.00	66.00
Pt	5000	12.00	50.00	80.00					

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