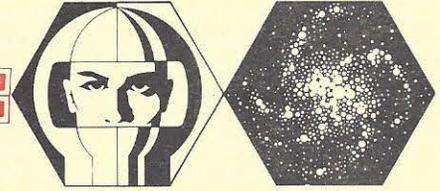


COMMERCIAL SPACE REPORT



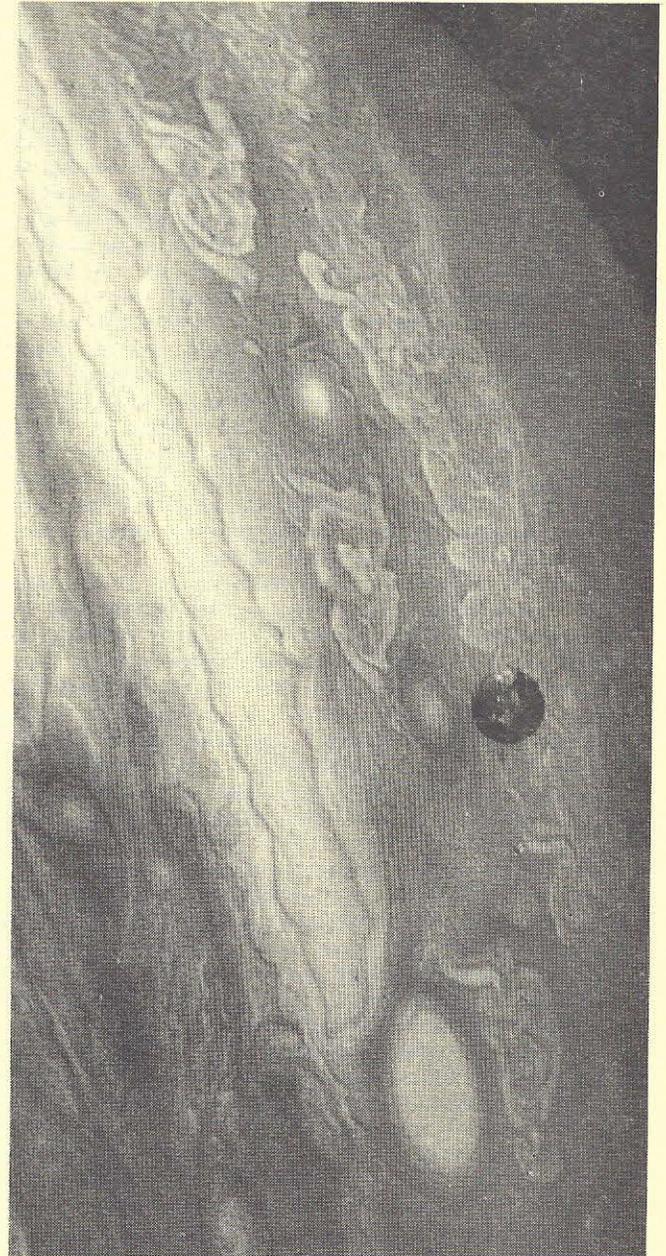
RESOURCES OF THE JOVIAN SYSTEM

Solar System Consists of Sun, Jupiter and "Debris"

It would be fascinating to go to another solar system and explore and exploit its planetary bodies. We know that there are other systems in the galaxy, but they are so far away that they are at present unattainable. Yet here in our own solar system is a planet almost large enough to be a star, and with it is what one might consider to be its own solar system. This system consists of diverse planetary bodies and a large central mass with its own intense radiation. It is surrounded by a set of planets that range in size from asteroids to the terrestrial planets. The crucial problem of transportation for astronomical units to the Jovian system is much less than to another star. Furthermore the information transmitted by Pioneer 10, 11 and the Voyagers have provided enough information to get a rough idea as to what resources are available. Assuming that a feasible transportation system is developed, further exploration would be done and detailed resource studies would be made. Meanwhile, the results of Voyager has provided enough tidbits of information to show that Jupiter's Galilean satellites could provide tremendous opportunities for use by humans.

In nature, a minable ore deposit occurs where geologic processes concentrate some useful mineral to the point where it can be either used directly or concentrated further by human actions. The concentrations of material are often a byproduct of some large cycle powered by some external energy source. On Earth, the effects of the sun, the moon, and radioactive elements on the hydrologic cycle and the rock cycle act to change the distribution of minerals and concentrate some as ore bodies. The source of energy for the Galilean satellites is not primarily from the sun because the sun is so far away. Jupiter's tidal forces and the presence of radioactive elements appear to be the primary sources of energy presently available to cause separation of minerals. It has been suggested by many scientists that some separation of materials occurred as Jupiter's system was forming as well. How the materials got there is a matter of debate. The fact is that there has been differentiation of the major satellites of Jupiter since their formation and there may be ways to make use of this.

The major satellites of Jupiter are named after the lovers of Jupiter from Greek mythology. The closest one to Jupiter (space wise) is Amalthea. Amalthea is a small planet three times the size of Phobos. It is shaped somewhat like a strawberry with its tip pointing to Jupiter and is one of the reddest objects in the solar system on the side that faces into the orbit. Deep in the magnetic field of Jupiter, it experiences intense radiation. Its density is about that expected of a rocky body. Other than that, little is known of Amalthea.

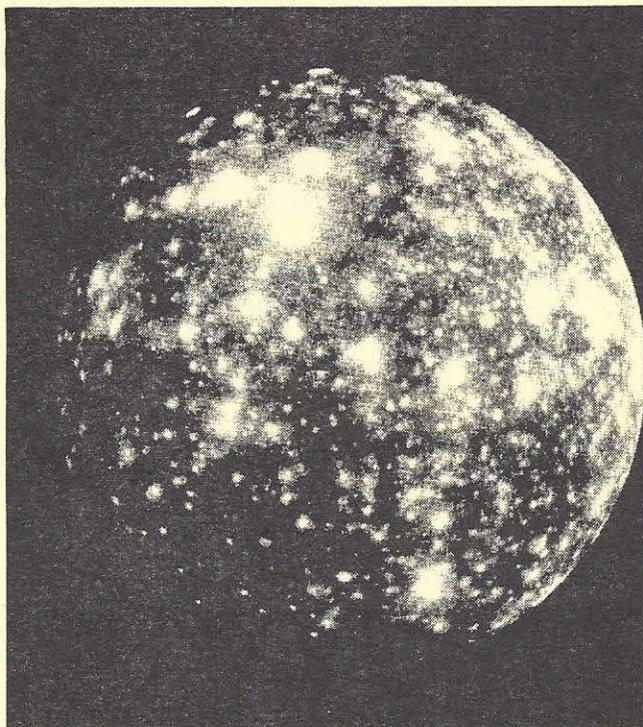


This photograph of the southern hemisphere of Jupiter was obtained by Voyager 2 on June 25, 1979, at a distance of 12 million kilometers (8 million miles). The Voyager spacecraft was rapidly nearing the giant planet, with closest approach to occur at 4:23 pm PDT on July 9. Seen in front of the turbulent clouds of the planet is Io, the innermost of the large Galilean satellites of Jupiter. Io is the size of our moon. Voyager discovered in early March that Io is the most volcanically active planetary body known in the solar system, with continuous eruptions much larger than any that take place on the Earth. The red, orange, and yellow colors of Io are thought to be deposits of sulfur and sulfur compounds produced in these eruptions. The smallest features in either Jupiter or Io that can be distinguished in this picture are about 200 kilometers (125 miles) across; this resolution, it is not yet possible to identify individual volcanic eruptions. Photo: NASA/JPL.

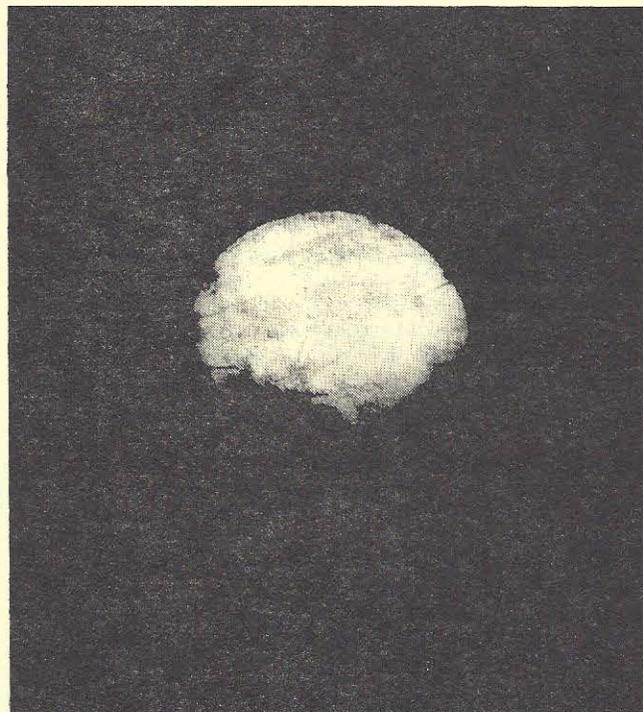
On the other hand Io is much better understood. The highest resolution of any of the Galilean satellites images are of Io. The surface of Io is virtually pristine, apparently covered by the activity of volcanoes on the surface. The seven active volcanoes observed appear to be distributed around the equator along arcuate lines. These volcanoes are erupting sulfurous material to heights of 250 km. Much of this material is destined to fall back upon the surface making it granular and porous. Sulfur, sodium and oxygen have been observed in space around Io. These materials are probably from the surface and volcanoes of Io and suggest the presence of extensive salt deposits. Many of the properties of Io are explained by a model which states that Io is a dry remnant of a planet that once had a great deal more water. Tidal, radioactive, and resistance heating (from the magnetic field of Jupiter) caused the water to be lost leaving the salts behind. Thus Io is a probable source of evaporites (minerals that form as residue from evaporating saline solutions). It is possible that radioactive salts could be concentrated due to their heating effects but further study is needed to determine this. The difference in temperature between the surface of Io (about 127K) and the molten sulfur (385K) expected at fairly shallow depths suggests that this source of heat could be trapped to use for industrial purposes. There are many large caldera like depressions with dark material in them as well as many hot spots. The fact that the volcanoes appear to be following some pattern in their distribution suggests that it may be possible to set up an industry safely on the surface. It may also be possible to power remote operations on other satellites or in space from Io.

Europa is the next planet out from Jupiter. At 9.5 Jupiter radii, it experiences less intense tidal friction but still has apparently been affected. It is slightly smaller than our Moon. About 20% of the body appears to be water and water ice. There are a few impact features from where meteorites have struck the surface. This implies that Europa too is an actively functioning planet although not as violently so as Io. Most of the surface is covered with ice frost. There are large dikes of relatively dark salty and/or siliceous material intruding the lighter salt and ice areas. The presence of ice, water, and less volatile materials provides a situation where materials can be separated on the basis of their differing solubilities. This holds great promise for mining a variety of salts which are leached from the rock below the water and ice crust. The action of differentiation by heat production of radioactive salts may be at work here as well. Although Europa is less extreme in the valuable temperature differences than Io, it may be better to operate on due to its greater safety.

Ganymede is the next planet out from Jupiter. It is larger than Mercury but smaller than Mars and is about 50% water. The surface is marked by grooves that are a few hundred feet deep and five to fifteen km wide. These grooves run for thousands of kilometers over the planet giving it the appearance of being stripmined. These grooves are apparently the result of movement of ice and possibly water masses within the body of the planet in response to thermal differences from the various heat sources mentioned above. Being 15.1 Jupiter radii out causes less tidal effects than Io or Europa experiences. As the planet cooled after formation it is expected that the salts would be concentrated at depth. Perhaps along these faults and grooves the salt solutions may have been squeezed up resulting in accessible deposits. As a site of industry Ganymede is poor due to the lack of extensive differentiation in the crust and lack of an obviously available energy source. It is however a good site for water and apparently has some ancient areas with pulverized meteorite fragments available at the surface. The interaction of the ice, meteorite fragments, tectonics, and perhaps salts could produce some useful deposits but



This image of Callisto was taken by Voyager 2 on July 7, 1979 at a range of 1,094,666 kilometers (677,000 miles) and is centered on 11 degrees N and 171 degrees W. The surface of Callisto is the most heavily cratered of the Galilean satellites and resembles ancient heavily cratered terrains on the moon, Mercury and Mars. The bright areas are ejecta thrown out by relatively young impact craters. A large ringed structure, probably an impact basin, is shown in the upper left part of the picture. A color version of this picture was constructed by compositing black and white images taken through the ultraviolet, clear and orange filters. Photo: NASA/JPL.



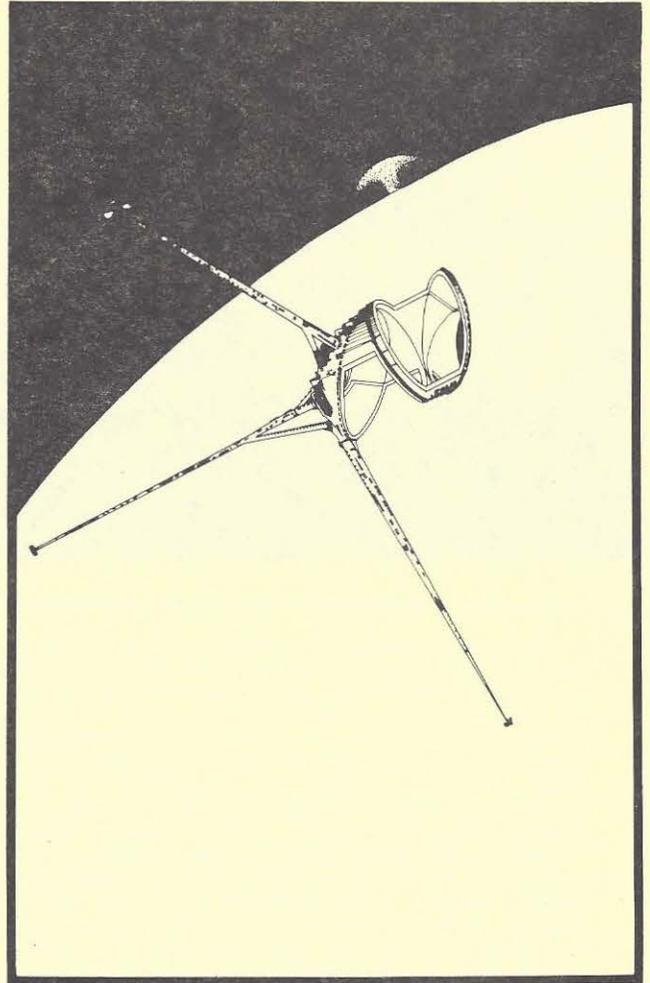
This image of Europa was taken by Voyager 2 about noon on Sunday, July 8, from a range of 1.2 million kilometers. It shows detail about 20 kilometers across and is somewhat higher resolution than the best Voyager 1 image. Color reconstruction in this image was slightly enhanced to bring out detail in the complicated mottled region on the west limb, containing some of the linear fracture-like features discovered by Voyager 1. Photo: NASA/JPL.



Right: This picture shows part of the surface of Ganymede as viewed from a range of 120,000 km by Voyager 2 on July 9th. In the foreground is typical grooved terrain as seen by Voyager 1. It consists of mutually intersecting bands of closely-spaced, parallel ridges and grooves. In the background is newly-cratered dark terrain across which can be traced several widely spaced parallel linear features. When viewed from a distance the line features appear to trace broad circular areas. The features resemble the circular ridges on Callisto that surround an almost completely annealed impact basin. The feature on Ganymede may be of similar origin but all traces of the impact itself have been destroyed. Photos: NASA/JPL.



Left: This picture of Ganymede was taken at a range of 169,000 km by Voyager 2 on July 9th. Dark contrast terrain is separated by bright bands of grooved terrain. The band of closely spaced linear grooves in the foreground is 150 km across and appears to be offset by another narrow band at right angles, as though by faulting. A variety of ray patterns are seen around craters. One is the left of the picture, it has prominent dark rays around an inner bright halo. Other craters have dark haloes; other have diffuse bright rays. The variation in albedo patterns around the craters may be indications of layering in the surface materials. The intensity of craters suggests the dark areas are extremely old. The bright grooved terrain is less cratered and probably somewhat younger.



Artist's conception of a power relay satellite in orbit over Io. "Geo" thermal energy from the moon's subsurface would be used to generate power which would energize lasers. The laser beam would be relayed to mine sites on the other satellites, such as Callisto or Ganymede. Artwork by George A. Singer.

at present too little is known to be of much use.

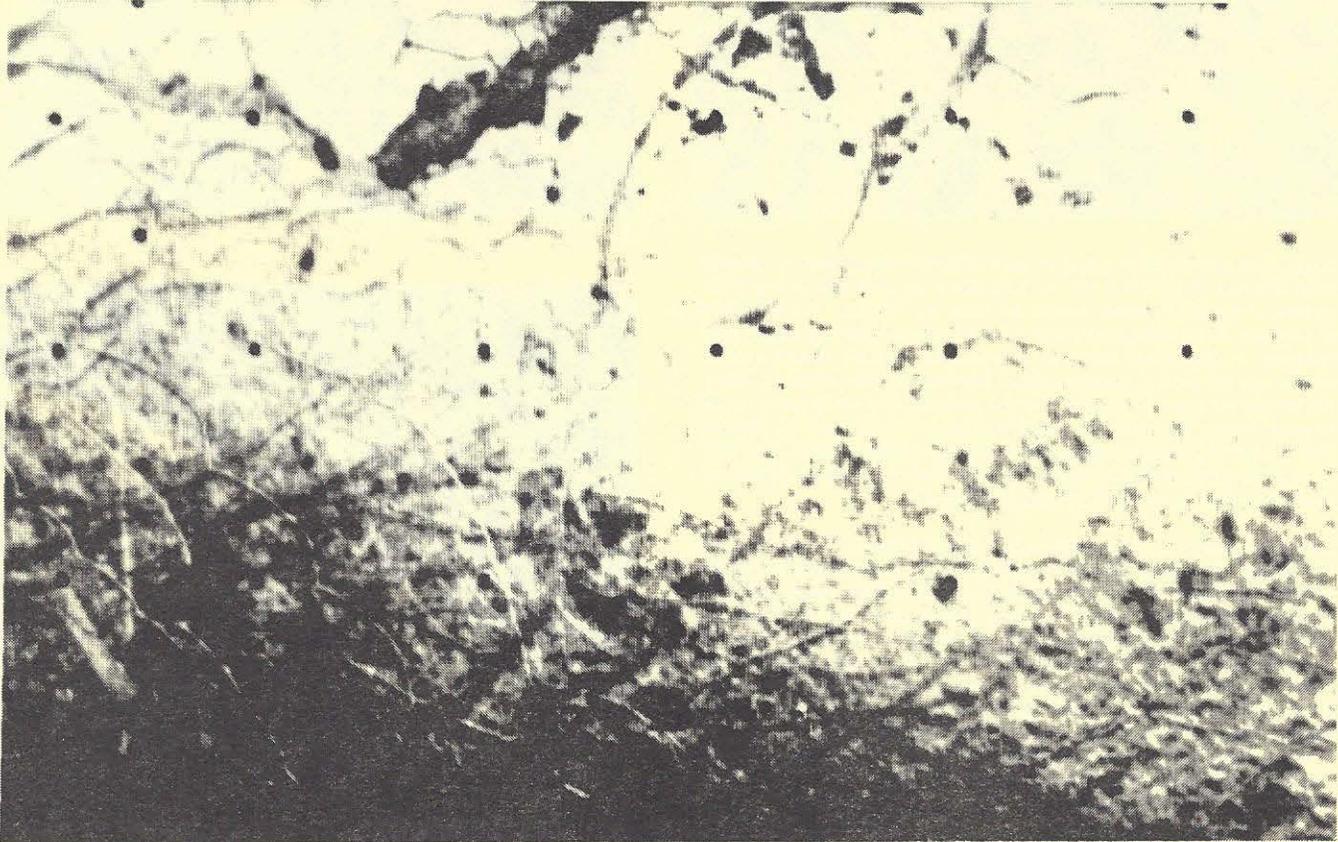
Callisto is the outermost of the major satellites. This planet is the darkest of the satellites yet is twice as bright as the moon and is about the size of Mercury. It is about 50% water and is expected to have a thick ice crust. The surface is littered with pulverized dark carbonaceous chondrite material from the numerous meteorite impacts. The large distance from Jupiter makes tidal forces unimportant. The planet does not appear to have any differentiation going on as do the other moons. The industrial potential of this body exists in its pulverized carbonaceous chondrites and in its water. There may be industrial processes that require water and/or gravity. The broken up nature of the chondrites may aid in processing of the material although it should be noted that broken up carbonaceous chondrite fragments and water are expected on some of the large main belt asteroids as well.

The Jovian System presents a unique opportunity to examine and possibly use a diverse set of planets. The unique advantages of these satellites stems from the

effect Jupiter has had on them. There is reason to believe that Jupiter's satellites may have vast stores of materials uniquely segregated by the effects of tidal dissipation in a cold icy part of our solar system. As such, our second "sun" (Jupiter) may provide a second (and possibly major) source of valuable energy and materials as radioactive elements, rare salts, and "geo"thermal energy. Thus it could be a way station for future extraterrestrial ventures or a mining center, supplying valuable commodities. It is far off and depends on advanced transportation systems to be useful but the extra trouble may well be worth it. More details will be known if the Gallileo mission (planned for 1986) or other Jovian missions are successful. □

Acknowledgement: Credit for organizing this article and Voyager images goes to Ms. Laurie Johansen.

This image of the Jovian moon Europa was taken by Voyager 2 July 9, 1979, as the spacecraft passed within 225,000 kilometers (140,625 miles). The area shown is about 600 by 800 kilometers, and the smallest features visible are about 4 kilometers in size. This image was taken along the evening terminator, which best shows the surface topography of complex narrow ridges, seen as curved bright streaks, 5 to 10 kilometers wide, and typically 100 kilometers in length. Also visible are dark bands, more diffuse in character, 20 to 40 kilometers wide and hundreds to thousands of kilometers in length. A few features are suggestive of impact craters but are rare, indicating that the surface thought to be dominantly ice is still active, perhaps warmed by tidal heating like Io. The larger icy satellites, Callisto and Ganymede, are evidently colder with much more rigid crusts and ancient impact craters. The complex intersecting of dark markings and bright ridges suggest that the surface has been fractured and material from beneath has welled up to fill the cracks. Photo: NASA/JPL.



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NEWS NOTES:

OTRAG UPDATE...Munich...In conversations with a **Report** representative at the recent 30th Congress of the International Astronautical Federation in Munich, OTRAG officials spoke of their plans for the future, following their ouster from Zaire. One of the points made was that the activities of OTRAG in Zaire are by no means finished: in contrast to what has been reported by the world press, OTRAG still retains its holdings there, but has been forbidden to fly any more test missions from the launch site. Future plans call for launching the next three test missions from a boat at sea, and negotiations are underway at the present time with six other nations concerning launch sites. OTRAG officials would not release the names of the prospective host nations. It was also determined that the company is in some financial difficulty, but whether this is serious enough to halt forthcoming flights is not known. OTRAG has raised \$67 million from 1400 wealthy German investors to date.

FRENCH COSMONAUT...Munich...It has been learned that the USSR has offered the French Government an opportunity to fly a French crewmember on a future Soviet manned space flight. Observers note that a woman candidate, turned down in a bid for a SpaceLab payload specialist position, might be chosen if the offer is accepted.

SOVIET SHUTTLE...The **Report** has learned that the Soviets may fly their mini-Shuttle during or around the time of the Moscow 1980 Olympics. The shuttle is reportedly similar in concept to the US DynaSoar configuration, an Air Force manned space project which was cancelled in the early 1960's. According to informed sources, there is no cargo bay on the USSR vehicle, and the primary mission is to transport a few crewmembers to orbital stations or for short scientific and military missions.

SPACE LAW BOOK...Delbert D. Smith, attorney and editor of Satellite Communications magazine, has finished a book titled: Space Stations: International Law and Policy. This book assesses the current and potential impact of space stations on international law and policy, with an emphasis on institutional and national concerns regarding ownership and operation of large space structures. Included is an analysis of applicable international treaties and conventions and their impact on space development. Available for \$22.00 from Westview Press, 5500 Central Avenue, Boulder, CO 80301. (254 pp.)

LUNAR TREATY UPDATE...Effort is being mobilized by concerned space observers to fight the proposed draft lunar treaty which has been reported out of committee and sent to the floor of the General Assembly of the United Nations. Several groups are preparing to fight ratification of the treaty when it is approved by the UN and sent to the Senate for approval. OMNI magazine, a well known science fact-fiction magazine, has even retained a lawyer to study the issue. Meanwhile, from

the IAF Congress in Munich, comes word that not everyone is concerned about the effects of the accord. Dr. Edward R. Finch, Jr. titled his paper given at that meeting: "1979 United Nations Moon Treaty Encourages Lunar Mining and Space Development". Finch feels that the treaty does not bar private activity in space, and in fact, pledges the US to only negotiate about the establishment of an "international regime", not actually to establish one. He quotes US Delegate Hosenball speaking at the UN on July 16, 1979 as saying: "The draft treaty, as part of the compromise by many delegates, places no moratorium upon exploitation of the natural resources on celestial bodies pending the establishment of an international regime. This permits orderly attempts to establish whether such exploitation is in fact feasible and practical by permitting experimental beginnings and then pilot operations, a process by which we will learn if it will ever be feasible to commercially exploit the mineral resources of celestial bodies." According to Finch, the international regime might take the form of an INTELSAT style organization, not necessarily the form of the regime described by the Law of the Sea agreement (i.e., The International Seabed Authority). No technology transfer is implied by the treaty, says Finch. He goes on to state: "Hasty analogies to the law of the sea can result in misleading presumptions and conclusions. Lawyers who have worked in outer space international law understand the dangers in attempting the application of analogies from elsewhere to the unique space environment". However, Finch seems to hold a minority position among private sector oriented US lawyers, who are mobilizing to contest the treaty as it is presently worded.