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NEWS CONFERENCE ON
VOYAGER 2-JUPITER ENCOUNTER

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WEDNESDAY, MAY 30, 1979

APPEARANCES:

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RODNEY A. MILLS	Program Manager, NASA Hq.
DR. EDWARD STONE	Project Scientist California Institute of Technology
DR. LAURENCE SODERBLOM	Imaging Team Deputy Team Leader U. S. Geological Survey
DR. NORMAN NESS	Magnetic Fields Goddard Space Flight Center
DR. JOHN C. PEARL	Infrared Spectroscopy and Radiometry, Goddard
DR. FREDERICK L. SCARF	Plasma Wave Science TRW Systems

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P R O C E E D I N G S

(10:30 a.m.)

MR. MC ROBERTS: Good morning. I'm Joe McRoberts, from NASA headquarters.

John Kley is passing around a little tablet there. Jot your names down and we will give you a copy of the transcript. Of course, if you don't need the transcript, why, whatever.

Transcripts will be available in about a week. We have pictures. Les Gaver, of course, has pictures. Bob McMillan, from JPL, is here and also has pictures. He also has background information and so forth.

John Kley is here from Goddard, and he can help you on any of the Goddard people or anything you want to know about that.

The news conference is being piped out to JPL, and we will start off with Rod Mills, the Program Manager at NASA Headquarters but, first, I want to just introduce Dr. Milton Mitz, program scientists, who is here in the audience.

All right, Rod, would you step up, please?

STATEMENT OF RODNEY MILLS
PROGRAM MANAGER
NASA HEADQUARTERS

MR. MILLS: Okay. Before we get to the science results, I just want to make a brief report on the mission status. It has been a couple of months since most of you have heard about it.

Voyager 1 is continuing on its way to Saturn, in good condition. As of noon today, it is 84½ million kilometers past Jupiter, and it's got about 725 million kilometers to go to Saturn.

Voyager 2, as of noon today, is 31.4 million kilometers from Jupiter, headed inward and, for reference, it is about 842 million kilometers from earth at this time.

Since we last spoke to most of you, there have been a couple of spacecraft events I want to discuss. First, Voyager 1 performed its large trajectory correction maneuver on April 9. That was about a 7.3 hour burn of the thrusters that imparted a delta-V of something like 64 meters per second; used up about 30 kilograms of our propellant and, at this time, we have left about 55 kilograms of propellant.

We anticipate that we can track Voyager 1 far out beyond Saturn, probably out maybe 30 AU or more.

Voyager 2 last Friday performed a minor trajectory correction maneuver to improve the aiming at Jupiter. That was just a small, about a 1½ meter per second adjustment in the velocity. It is now on a good trajectory for Jupiter which, of course, it will reach on July 9.

Voyager 2 has been in the encounter period since April 24. It has been in the observatory phase observing Jupiter around the clock.

For the last few days, the spacecraft has been involved in obtaining a five-rotation movie of Jupiter. Now, yesterday we started the far Encounter 1 observations.

Everything is going well with the spacecraft. If you will remember, it is the one that has radio problems -- that is, it's primary radio failed quite sometime ago, and its secondary radio, which we are using to command it, has a a shorted capacitor which somewhat limits the frequency tracking capability. But we have had no recent problems in commanding, and everything looks like "go" for the encounter.

I think that's all I have to say, so onward with the science report.

MR. MC ROBERTS: Okay. Our first science report will be from John Pearl on Infrared Spectroscopy and Radiometry, from Goddard Space Flight Center.

STATEMENT OF JOHN C. PEARL
INFRARED SPECTROSCOPY AND RADIOMETRY
GODDARD SPACE FLIGHT CENTER

MR. PEARL: Thank you, and good morning.

Our instrument has two parts; one is a radiometer channel which integrates over most of the solar spectrum, from about .3 of a micron out to about 2 microns, and the other is an infrared spectrometer.

As you are probably aware, spectrometers split up the energy into its various wavelength components, such as you see a prism or a raindrop with solar radiation breaking it into its spectrum of colors.

Our instrument does the same thing with the infrared, essentially, breaking the heat radiation up into its what you might call "infrared colors".

The results I would like to discuss today are results from the spectrometer.

Amalthea is the innermost moon of Jupiter. Its diameter, if you take an average diameter, it is about a 20th or a little more of the diameter of the earth's moon. On the flyby of Jupiter, we got a glimpse of it when the spacecraft was about the same distance from it as the earth is from the earth's moon.

At that time, the satellite only filled about 1 percent of our field of view, and the data that we got were somewhat noisy. The first slide shows the spectrum that we got. As I said, the data were noisy. We plotted the intensity, as a function of the, call it the "infrared color" defined by wave number.

For those of you who like to think in terms of wavelengths, the wave number is the reciprocal of the wavelength. 200 wave numbers is 50 micrometers, 400 is 25, 1,000 is 10 micrometers.

The solid curves you see superimposed on the data represent the spectrum that we would see if the object we were looking at had the temperatures indicated.

As you can see, even though the data are noisy, it is evident that a fit of something around 180 kelvin for the temperature of Amalthea fits the data very well. And deviations of 10 degrees from that are clearly unacceptable.

This is significant because the temperature of Amalthea, if it were only heated by the sun, could not exceed 170 kelvin. Consequently, there is increment in energy to take it from 170 to 180K, which comes from something other than the sun.

Radiation from Jupiter alone will not do it. The source of this additional energy is now believed to be impact by very high energy particles in the Jovian radiation belt. A minor contribution might also be made by electrical currents flowing through the satellite, due to the fact that it is moving through the magnetic field around Jupiter.

If I may have the next slide. We were fortunate, in the observations of Io, to see several anomalously warm places. You can see two of them on this figure, one corresponds to the area in the upper right, the dark area above the brighter region, and the other area corresponds to the dark, annular area just above center on the left.

Schematically, our observation of that feature is represented, as shown here. It contains some dark areas which are believed to be warmer than the surrounding area. This includes that annular, doughnut-shaped region and that elongated, dark region above it.

It is known from other images that a plume of gas and dust is evolving from one end of the linear feature.

Now, if we consider the fact that the dark areas are a different temperature from the light background, then we can make a fit to the data just by assuming that the dark areas are at one temperature and the light areas at another temperature and, if we do that, we get a set of curves that looks like this.

The dark curve represents the intensity as a function of wave number that we measure, the heavy dark curve, and the two dotted and dashed curves represent components from two different temperatures.

We assume that if 9 percent of the field is at 280 kelvin, then the contribution to the data from an object like that would give you the short, dashed curve. That leaves the remaining 91 percent at some other temperature.

If we take 125 kelvin for that temperature, then we get the longer, dashed curve and, if we add them together, we get the thin, solid curve, which fits the data reasonably well. Considering the fact that the model is so simple, it really does very well.

We vary the parameters a little bit, try to take different temperatures and so on, and we find that, on the whole, the dark areas, or large fractions of them, must be somewhere between 280 kelvin and 300 kelvin, and the background should be between 125 and 130 kelvin, and that isn't too far from what one would expect for the background temperature if it were just heated by the sun.

The 9 percent, actually, is derived from the fit. We make a three-parameter fit; one is the fraction of the area of the hot temperature, and the other is the remainder. And the 9 percent corresponds quite well, actually, to the dark regions in the field of view.

So, again, it's confirmatory, since it is an independent evaluation parameter. If we use slightly higher temperatures, why, then, that 9 percent figure drops down to something closer to 6. But, again, it is still consistent with the quality of the fit to those areas being roughly at those temperatures.

If we try to force the hot area to be the temperature of molten sulfur, since people are interested in whether molten sulfur might exist, the fit gets very poor. We cannot have more than about 1 percent of our field filled by molten sulfur.

QUESTION: What is that temperature?

MR. PEARL: About 385 kelvin.

Now, getting to the plume, the material in the plume will partially obscure the surface. If there is any atmosphere on Io, this would do the same thing.

The characteristic of the material, or materials, which might be present in the atmosphere, or the plume, will, in fact, make the obscuration different at different wavelengths or wave numbers.

And if we look at our spectrum, we find an area which has a very noticeable absorption feature shown on the top part of this figure, where we have plotted the intensity, again, as a function of wave number, and the deep feature there we have identified as being due to the sulfur dioxide gas.

This would be evolving from the volcano. It is present in the volcanic gases on the earth, and it is not at all unexpected on a planet like Io which has as much sulfur in it as is believed to be the case.

Below it, we have calculated sulfur dioxide gas transmission spectrum and, beneath that, an SO2 ice transmission spectrum. It is clear from this that the feature we see is coming from gas rather than from the solid -- that is, we are not seeing snowflakes or crystalline material which is thrown up, but we are seeing the gas which is evolving from the volcano, or evaporating from the surface.

The amount of SO2 is very low. It's less than a millionth of the earth's atmosphere. We have looked for other materials which are found in terrestrial volcanos, particularly water, vapor and carbon dioxide, which are very common components and, if they are present, they are present in very, very low quantities.

And this would imply a lack of hydrogen and carbon in Io, which would be considered consistent with the hypothesis that Io has been volcanically very active throughout its history.

Thank you.

MR. MC ROBERTS: Our next speaker will be Dr. Laurence Soderblom, Imaging Team Deputy Team Leader, U. S. Geological Survey.

STATEMENT OF DR. LAURENCE SODERBLOM
IMAGING TEAM DEPUTY TEAM LEADER
U.S. GEOLOGICAL SURVEY

DR. SODERBLOM: Could I have the next slide, please?

I will summarize the results that we have gotten to the last month of analysis or so, to summarize for you with respect to the large Galilean satellites -- Europa, Ganymede and Callisto.

Ganymede and Callisto, the outer two Galilean satellites, are both about the size of the planet Mercury. Their revised densities now are, Ganymede, 1.93 and Callisto, 1.79. Callisto has been brought up in density, as its diameter was refined in Voyager images.

So, the two have densities very close to 2, and this confirms that a substantial fraction of their interior is water.

Europa's density is close to 3.0. It had been oscillating between 3.0 and 3.2, suggesting that a substantial fraction of the upper crust of Europa is probably or water-ice, as was thought from earth base.

Going on to the next, Amalthea, the innermost of the Galilean satellites, is shown here in three views. The bright spot Jonathan Eberhardt asked me to mention is not a searchlight on Amalthea, it is an exaggeration due to the processing.

The body actually has an albedo between 4 and 6 percent. It is very red. The bright spot has an albedo close to 15 percent, so it's a fairly dark material, and the bright spots are actually gray spots. They are essentially colorless relative to the rest of the body. The rest of the body is very uniform in color.

The size of Amalthea is roughly 250 by 125 or so kilometers. It is elongated with long axis pointed toward Jupiter, as it rotates synchronously about the primary.

You can see, portrayed here are the three views. Each of the views corresponds to one of the little cartoons. You can see that the lower left shows the leading hemisphere of Amalthea, and the upper right, the trailing. The lower right is an edge-on view.

You can see, I think, these two spots over here correspond to these two points here. This is a summary of some of the volcanic observations. Shown here are sets for two of the centers, two types. The upper one erupts from a very symmetrical vent area shown in "a" there. "b" shows the view from about a 45 degree viewing angle, and shows the material erupting from that plume is dark material. In other words, the albedo of the material as it is coming out is dark.

We suspect now that the difference between "a" and "b" is not purely an optical effect, that it represents some time variability in the eruption over a period of hours to days.

The lower one is one John Pearl just talked about. You can see that it has a very diffused, irregular character. The nature of the plume probably is controlled by constriction of the nature of the vent or throat in the vent area.

The volcanos are distributed widely through the equatorial belt, and they are associated, the symmetrical ones, with these rings you see here, and there are two of them. The regular ones -- this is the first one discovered, the big heart-shaped plume. The regular ones -- here, again, is the one that John Pearl talked about here. Here's another one up here, about 20 north and about 30 north.

All of the plumes seem, so far, up here to be within about 30 degrees of the equator, which is peculiar, since the tidal heating model of Peale all suggests that most of the energy is deposited in four regions, according to the verbal report from them.

So, something may be going on in the polar regions, which is different from the equatorial regions, and that may be different rates of resurfacing or deposit of material.

The analysis of the absence of craters, if that is allowable, suggests that if the Jovian system is getting impact rates at the rates which we project, knowing what the impact rates are on the moon, the rates could be higher, but not substantially lower than the model predictions, suggests that one crater about a kilometer in diameter would be formed every 50,000 years or so, on a body this size.

None has been seen. That suggests that a rate of burial of at least a millimeter a year, planetwide, is required to erase these. That is, in fact, consistent with estimates the Imaging Team has made in terms of the amount of material that is coming out of the vents.

So, averaging 15-some vents over the surface, that is consistent with the absence of the craters.

The features that I want to refer to now are faintly visible down here. You can see them as little wisps of bluish material. If we could get the light up sometime, perhaps in another session, you would be able to see them a little better.

They are actually scattered throughout the south polar region. This is an enlargement of that section. There are three of them here, a collection of them here. Wherever you see this bluish appearance, the image looks as if it is out of focus, as if it is diffused. Throughout this region down here, you will see this, again, bluish cast down here as well, and it has the character of a very fuzzy appearance.

QUESTION: How long did you expose it?

DR. SODERBLOM: This exposure? I would guess about 100 milliseconds. It's actually made up of three different colors, so there is a combination of exposures. But to the question, is it smeared, the answer is "no". If you look at edges of other features in the image, in particular, things such as this, they are well defined and so forth.

So, it is a fuzzy character, and we suspected that these things might have been airborne. Now, this is a high resolution image near the terminator, and this is what they appear to be near the terminator. They are bluish. They tend to form along faults or fractures in the crust, and appear to be something issuing from the crust.

This is a comparison of two images acquired about six hours apart. The one on the left is not out of focus. It is a section of that global view I just showed you. It shows a ring of three colored areas here, here and here, which have dark material, dark pools in the floor of still questionable material, but the one on the right was taken just prior to near encounter.

The bluish glow along the edge of the top vent has developed in a period of about six hours. It is similar, in appearance and in spectral character, to the bluish areas I was showing you just on the previous slide.

And the suggestion here is that these are, in fact, eruptions of probably gas and, with the IRIS indication of SO2, SO2 is a good possibility. SO2 would, in issuing in a dense cloud from these fractures and so forth, begin to condense and snow-out of the atmosphere very rapidly. And since its partial pressure at that temperature is very low, then this freezing gas would form very fine particles which scatters light very much like gas. In other words, it would scatter preferentially in the blue.

These areas of bluish glow are brighter than the surface at all these places as well, and so the component, which would be coarses snow particles, could be explaining the brightness at all wavelengths.

QUESTION: Is that real color contrast to the eye?

DR. SODERBLOM: You could see it, definitely. Whether or not the colors would be identically this, or the turquoise would be a little greener or a little bluer --

QUESTION: This extreme is really what I'm asking.

DR. SODERBLOM: It would be this extreme. As a matter of fact, we looked at this, and the violet brightness in that area is 15 times higher in the later image than in the earlier image. So, it is that extreme. It is brighter than the surface, and also we confirmed that it did brighten up in the blue as well as the violet, but not as much, but that actually happened at two wavelengths, so it was not an artifact of one part of the image going to saturation or some strange effect like that.

Okay. That's all I have. Thank you.

MR. MC ROBERTS: The next speaker will be Dr. Frederick L. Scarf, Plasma Wave Science, TRW Systems.

STATEMENT OF DR. FREDERICK L. SCARF
PLASMA WAVE SCIENCE
TRW SYSTEMS

DR. SCARF: I would like to talk about lightning at Jupiter today. I would like to start out with the first slide that is actually from the Imaging Team.

When we were leaving JPL, we had a release of a picture taken when the spacecraft was looking at the dark planet. There were glows that were identified as lightning by members of the Imaging Team, and there were other displays that appeared to be connected with the aurora.

This is another version of that picture in which the auroral part doesn't appear, but you can see the correct placement of the frame on the planet, on the dark side of the planet, and you can see the bright glows that have been identified as lightning.

Now, a wave experiment in orbit around a planet like Jupiter has, naturally, a possibility of detecting radio signals from lightning , and I would like to go on to the next slide and describe the way we tried to search for this.

Here we have Jupiter, obviously, with the red spot, and the Io torus. This is where we were when we were doing these things. There is a lightning bolt in the atmosphere that is, in fact, a very long antenna for transmission or excitation of radio waves.

A lightning bolt has an extent of several kilometers, and it makes, very efficiently, low frequency radio waves that travel off and are detectable out in space, or out in the magnetized plasma.

We have tried to indicate here a very significant aspect of this detection, and that is the medium, the plasma above the atmosphere, actually has the characteristic so that the high frequency waves go more easily. They go faster out to the spacecraft than the low frequency waves, come more slowly and arrive less.

So, if we are really looking, searching, for whistlers, we should listen for a signal that has high frequency components arriving, and then, finally, the low frequency ones arrive. And the name "whistler" then comes from this shape.

Now, soon after the press activities on Voyager 1 were over, we started to get high rate data -- we need our waveform or audio data to search for this -- and we found a number of these. And my colleague, Don Gurnett, had a press release just describing the detection of these whistlers. But there is so much other noise out there in the magnetosphere that we had no capability of playing these for you at that time and, since then, we've had a little more data coming in, high rate data, and I thought I would talk about a better example, and let you hear it, too, today.

The next slide shows the kind of voice print that we use to display what is coming in on the high rate data. The frequency goes up and the time goes along, and each segment that we get is 48 seconds long.

And these are two lightning whistlers detected when we were in the Io torus at about 6 Jupiter radii. They came in fairly late to our laboratory, so we weren't able to talk about these earlier.

The sounds that are associated with this are signals that fall with frequency. It is a very characteristic indicator of lightning generation. Now, you see in the bottom of this frequency time diagram, there is a lot of blackness.

This is a hiss that is present in the magnetosphere of Jupiter, and I will come back to explain the significance of this in just a moment, but let me play a little bit of this audiotape starting a few seconds before the first whistler. You will hear the hiss, then the first whistlor; the second one that comes about 8 seconds later is a little harder to hear, and then I have recorded on this a repeat of the whole thing.

If this doesn't work too well, I have a louder version in my pocket. So, let's start with this.

(Whereupon, an audiotape was played.)

Well, so much for the sound. I hope that was adequate.

We detected, in the early part of our discussions, about 40 of these. And Don Gurnett discussed that in the press release, and he will be talking about the analysis tomorrow, connected with this. And I think now we have many more, almost twice as many at this point, as the high rate data keep coming in.

The lightning and the whistlers are very important for a number of reasons. First of all, the question of lightning on Jupiter, in the atmosphere, is significant; significant in terms of the chemistry that can go on there.

There are many reactions that are modified strongly by the presence of lightning and there was an extensive literature before we got there, speculating on the importance of lightning on Jupiter, based on the fact that certain elements -- I'm sorry -- certain compounds were detected in abundances that didn't appear to be natural.

The other important aspect of detecting lightning such as this, is that the lightning travels along the magnetic field lines that are not accessible for Voyager. Voyager stayed near the equator. These signals come at high latitudes along the field lines and, by analyzing the properties of these signals, we can actually deduce the density of the plasma up at high latitudes, all the way down to the atmosphere. And this is not an insignificant thing because, from where we were in the Io torus down to the atmosphere, the distance along that field line is a solar radius. It's a long way to go for the signal that you have just heard.

The final reason that I want to talk about concerning the importance of whistlers is indicated on the next slide. Can I have the last slide?

These radio signals have frequencies that happen to match up with frequencies of electrons spiraling around the field lines, trapped electrons in the high energy radiation belts of Jupiter.

And when people first started to worry about whistler noise, such as this, in the earth's magnetosphere, then it was recognized that these signals could do very severe things to the trapped electrons.

What we have tried to suggest here is that, in a situation in which there is no such noise, plasma wave, the electron would just make its spiral and go back and forth. But if it interacts with a wave of this type, such as the situation in the blue plasma torus region, it can get a kick, as if someone was swinging and you hit them with the right frequency. You can get a kick and go in another direction and, in fact, no longer spiral along the field lines, and go down into the atmosphere in which it produces auroral type displays, extra ionization and even heating.

Now, in the earth, whistlers such as this are detected, but there are not enough of them to do very much to the trapped Van Allen belts. At Jupiter, we have detected a number, and we can make the same statement. There are not enough whistlers to do much here.

But that other noise that you heard on the tape, the hiss, is, in fact, the same kind of radiation -- it is spontaneously generated inside the magnetosphere -- and it does do a lot of this ejection of electrons down to the atmosphere. In fact, the amount of energy that comes into the upper atmosphere, from this mechanism, is an order of magnitude more than sunlight.

That's all I have.

MR. MC ROBERTS: Our next speaker will be Dr. Norman Ness, Magnetic Fields, from Goddard.

STATEMENT OF DR. NORMAN NESS
MAGNETIC FIELDS
GODDARD SPACE FLIGHT CENTER

DR. NESS: I don't know if you can read this first Vu-graph, but it represents the players on the Magnetometer Team. It's been a team effort, as are all of the individual experiments on the spacecraft.

There are copies of the handout, which have this as the top page, which include all of the figures which I will be using. There are also copies of our science paper available in the back.

I'm going to start off by putting up my summary first. The reason I want to do that is, there are times when people have some difficulty appreciating the significance of the results in the more exotic realm of the plasma environment of Jupiter.

Two principal new results I want to report on have to do with the configuration of the outer magnetosphere of Jupiter. Those are listed in the summary as Items 2, 3 and 4. Following Pioneer 10 and 11 observations, it was interpreted that the magnetosphere of Jupiter was somewhat unlike earth, and it was like a squashed down magnetosphere of earth, a magnetodisc it is called -- rigid or floppy.

A great theoretical effort was expended upon attempts to utilize the data to validate one or the other of these two models. These are both axisymmetric, no local time dependence.

What we find, in fact, in the Voyager 1 observations, is that the outer magnetosphere of Jupiter is not represented at all well by either of these models. And, in fact, it appears that Jupiter possesses a very large magnetic tail much like earth, although the inner part of the magnetosphere is significantly different.

This is an enormous magnetic tail, 3- or 400 Jovian radii in diameter. The implication of the magnetic tail is important for auroral phenomenon and radio emissions from the planet, because the existence of the large magnetic tail implies a very eccentric polar cap auroral region and, by "eccentric", I mean that it is not coaxial either with the rotational axis of the planet or the magnetic axis of the planet, quite unlike in the case of the earth, in which the auroral zone is roughly, but because of the solar distortion, not quite symmetrical about the magnetic axis of the earth. That is Item 1, the outer magnetosphere configuration, the existence of the magnetic tail of the planet.

The second item has to do with Item 6, our interpretation of the perturbations of the magnetic field in the vicinity of Io, associated with the Io flux tube. This is not an exotic process. This is well known to us. I would use the analogy that this is a great big power station in the sky, much like a hydroelectric power station, but instead of hot water providing the power and the generators, what we have is Io as the conductor, and the power comes from the magnetic field of the planet Jupiter, which is swept past Io at a very rapid rate.

It generates a very large current. In fact, the current may be sufficiently large that ordinary resistive losses, Joule heating, may be an important factor in the thermal evolution and the present status of Io and its atmosphere. That is my summary.

I would like to lead you briefly, quickly, through the various figures which discuss this; then put the summary slide back up and once, again, hit you with those two major points, the magnetic tail and the power station.

I thought it would be appropriate to show a nicely done conception of the earth's magnetosphere, to give you some idea of the contrasting ideas that existed prior to Voyager 1 with respect to the Jovian magnetosphere.

In this diagram, the yellow indicates the flow of solar wind from the sun; the blue region, looking like a comet tail trailing behind the earth, represents the distorted earth's magnetic field and magnetosphere.

Imbedded within the magnetosphere are the radiation belts and many other phenomena related to geospace. Now, in the case of Jupiter, about ten years ago it was thought that because of the very rapid rotation and the massive gravitational field that the magnetosphere of Jupiter would be drastically different than this configuration, which is highly local time dependent.

The day side is where the subsolar point is compressed, on the night side the magnetic tail is extended far beyond the orbit of the moon.

This diagram taken from a work by Piddington shows the configuration now looking down on the equatorial plane, from the north polar region, indicating that it was thought that the magnetic tail of Jupiter, instead of extending behind Jupiter, which would be downward in this particular figure, would, in fact, be wrapped around the planet.

That concept about the importance of the rapid rotation, the massive gravitational and magnetic field would lead to a significantly different configuration for the magnetosphere stayed with us through much of the recent times following the interpretation of Pioneer data.

This view in the noon-midnight meridian plane shows a configuration of the confined magnetosphere of Jupiter, but inside you can see the distortion of the magnetic field in which, in this diagram, it shows the floppy magnetodisc in which there is a curved equatorial region.

The rigid magnetodisc would simply extend the field lines in a symmetrical fashion relative to the magnetic axis.

Well, what we have found from the observations on Voyager, retrospectively reviewing the observations of Pioneer 10 and 11, are that, in fact, it appears that there is a very large magnetic tail outside this distorted magnetosphere region.

That current sheet, which is close to the planet, and the distortion of the field lines in the equatorial region as shown, merges with a neutral sheet region on the night side -- that is, in the tailward region -- and, as the planet rotates, because of the tilt of the dipole axis by about 9.6 degrees relative to the rotational axis, this current sheet wobbles for the period of ten hours, the rotational period of Jupiter, and that the multiple observations of the current sheet, both by the Pioneers and by Voyager, and the topology of the magnetic field as observed by these spacecraft, especially on the night side, can be best explained by the existence of this large magnetic tail.

Now, the implication of that large magnetic tail is shown in this diagram in which we have now traced the field lines, which would be located in the magnetic field, down to the surface of the planet.

On the left-hand side, we have shown the northern region, and the auroral zone is delineated by those field lines which represent the boundary between tailward field lines and magnetic field lines which, essentially, corotate with the planet.

The colatitudes are indicated 10-20-30 degrees. You can see that the auroral zone in the northern region is quite offset from being coaxial with either the rotational axis of the planet, which is the origin of the coordinate system, or even the magnetic dipole axis, which is the cross with the circle around it.

This is in distinct contrast to the southern polar region, which is much more like the earth, in which the auroral zone extends around both the magnetic axis and the rotation axis.

The implication of this high eccentricity of the polar region for the magnetosphere of Jupiter is that the radio emissions from this region will be much like a searchlight beaming into space for the period of ten hours, periodically immersing either spacecraft or the earth in its beam pattern.

Depending upon the strength and the frequency and the location of the radio sources in the auroral regions, it is also possible that they will be seen at periods of twice the rotation frequency -- that would be approximately every five hours.

The magnetic field geometry of Jupiter is very complex. The effect of the eccentric polar cap, the auroral zone will have to be studied further with more quantitative modeling.

An important feature of this particular magnetic tail model is that we predict that aurora will be seen as low, as you can see here, 30 degrees colatitude which is 60 degrees latitude -- it's a very low latitude region and, in fact, corresponds, I believe, to the lowest latitude at which aurora happened to be reported in the imaging experiment on Voyager 1.

Obviously, additional analysis of the experimental observations of auroral phenomena by the spacecraft Voyager 1 and 2 will confirm, hopefully, and lend support to this particular magnetic tail field model of the Jovian magnetosphere.

Let me now turn to the interaction of Io with the magnetosphere of Jupiter. The flux tube of Io is that region of space in the Jovian magnetosphere which is magnetically connected to Io and the surface of the planet.

The theoretical prediction of this strong interaction, electrodynamically, between Io and its magnetosphere, was done more than a decade ago by Piddington and Drake and by Goldreich and Peale and, subsequently, followed up by a number of other authors, including the original authors themselves. And the induced current pattern is shown here, in red and blue.

On the side of Io towards Jupiter, the current flows upward towards Io and, outside this flux tube region, the current flows downward. Now, Voyager was targeted to pass through this flux tube region on the basis that there would be no distortion of the magnetic field due to the electrical current which was flowing in the flux tube, itself.

As it has turned out, a very large current, in fact, was flowing at the time we passed through this region, and this led to distortion of the flux tube in the vicinity of both Io and especially in the vicinity of the Voyager 1 spacecraft.

So, we believe we did not pass through the flux tube as originally planned, although we did detect the effects of the induced currents which flow. The currents which flow are very large. They are approximately 4 to 6 million amperes.

The power generated in this system is 10 to the 12th watts -- that's a mega-megawatt. It is continuously generated by the interaction between Io and the Jovian magnetic field.

It's a rather complex interaction, and I would like to spend just a little bit of time on the more technical aspect of our data and its interpretation, since this is the first time, to my knowledge, that we have evidence for such a generation mechanism in astrophysics.

What we see here projected on a plane perpendicular to the average field direction in the vicinity of Io are the perturbation magnetic fields, the black vectors with arrows, shown as the spacecraft Voyager 1 passed by on the trajectory illustrated by the black dots.

Our interpretation of the location and configuration of the current which flows is indicated by the circle containing red and blue colored dots. The current flowing upward and downward is indicated in the same polarity definition used in the previous slide.

As you can see in this interpretation, the current flow occurs not in the region in which the spacecraft trajectory passed but, in fact, some 6- to 7,000 kilometers away from it. The direction in which it is removed is forward of Io and the spacecraft in the sense of the direction in which Io moves. But, in fact, more importantly, that is the direction in which the corotating magnetic field of Jupiter is carried past Io, since the rotation -- the orbital rate of Io is slower than the corotation period.

This is an important feature when one wants to determine the polarity of the current flow pattern.

Now, the configuration of the currents, in fact, are not parallel to the local magnetic field. There develops a rather exotic process which a few years ago, in the literature in studying the interaction of satellites moving in the earth's magnetic field, was referred to as Alfven wings, named after the Swedish astrophysicist, Thomas Alfven, in the light of the propagation of disturbances in a magnetized median, in this case, the Jovian magnetosphere.

This diagram shows the magnetic field lines as light, broken lines, and the current flow as the solid, heavier lines showing that the current flow is not parallel to the magnetic field. The reason for this is that the disturbances cannot propagate at the speed of light.

They are in a magnetized median. They are limited at the rate they can propagate a disturbance to the Alfven speed, and this deflection of the current from the magnetic field is what is referred to as "Alfven wings".

This current flow is shown leaving the field, both above and below, and then being reflected off what was in a completely unanticipated aspect of the magnetosphere, the torus boundary.

The Alfvenic current leaks down into the ionisphere of Jupiter, as well as being reflected back into the torus, itself.

In summary then, and I will reverse the order, since I have just been discussing Alfven wings, in confirming our identification of the perturbation of the magnetic field in the vicinity of Io, due to the electrodynamic interaction of Io with the magnetic field of Jupiter, we come to the conclusion that Io and the interaction represent an enormous power station generating sufficient current whose energy dissipation is adequate to heat the interior of Io by a mechanism analogous to that which toasts your bread in the toaster in the morning, resistive heating.

It is possible that the current flow, however, does not pass through Io itself, but only through the ionisphere of Io which is created by the energization of the gases given off by the volcanic emissions.

Only by joint study of magnetic field, plasma and particle data will we be able to elucidate the nature of the interaction in the immediate vicinity of Io and determine whether or not resistive Joule heating is an important factor to consider in the thermal evolution of Io, itself.

We will not, however, have to contend with the issue of how much power is involved. We have measured the total current which flows. We know the voltage drop across which that current flows. 10 to the 12th watts, approximately, is what is involved in this current power system, and that power is dissipated someplace within the Jovian magnetosphere. Exactly where is, obviously, critically important for certain mechanisms.

And, lastly, the magnetic tail of Jupiter, an enormous, large, extended magnetic field trailing behind the planet much like a cometary tail, pointing away from the sun, almost, but, in fact, away from the sun, as determined by the solar wind which comes from the sun.

The polar cap in the northern region at Jupiter is very eccentric and, unquestionably, is an important factor in determining the nature of radio emissions from the polar emission periodicities.

MR. MC ROBERTS: Our next and last speaker will be Dr. Edward Stone, Project Scientist, California Institute of Technology.

After Dr. Stone speaks, we want the investigators to come up to the front for the interview.

STATEMENT OF DR. EDWARD STONE
PROJECT SCIENTIST
CALIFORNIA INSTITUTE OF TECHNOLOGY

DR. STONE: Just a few brief comments on some science results, and then a little discussion about Voyager 2.

As you may recall, it was reported in March when we had our encounter activities, that the distribution of particles in the torus, as measured by the plasma instrument, indicated that there was ionized sulfur in the torus, and ionized oxygen in the torus, and that these particles were, basically, very low energy particles, which were essentially rotating with Jupiter's magnetic field.

Since that time, the cosmic ray instrument which, in fact, R. E. Voght is the principal investigator of, made some measurements of high energy particles, those moving with about 10 percent of the velocity of light, inside of Io's orbit -- again, just at the time when Voyager went inside the torus and was on its way back out through the flux tube. And at that time, discovered that the high energy particles also have a very anomalous composition.

At the bottom of this graph, you see the element number -- 6 is carbon, 8 is oxygen, 10 ion, 12 magnesium, 14 is silicon, 16 is sulfur and 26 is iron. And the bottom graph, basically, shows the kind of relative abundances that one expects for solar system composition; for instance, about half as much carbon as oxygen, and the appropriate amounts of even elements all the way up to iron.

Inside of Io, what was observed -- again, these were particles moving with about 10 percent the velocity of light, so they have been somehow accelerated from the plasma which was observed there, up to fairly high velocities, and what one sees is predominantly oxygen, no evidence of any carbon whatsoever.

The amount of sulfur there is about 75 percent that of oxygen and, in solar system abundances, the amount of sulfur is about 2 percent as, in fact, you can see in the lower plot, and the amount of sodium is also enhanced. In this case, the sodium is about 4 percent of oxygen while, in nature, it is about 2 percent in solar system abundances.

Compared to carbon, of course, all three are grossly enhanced. This, of course, is -- the relative abundances here of oxygen and sulfur are certainly reminiscent of a process which may well be related to what was reported this morning -- that is, that there is sulfur dioxide possibly coming out of the volcanos, that that sulfur dioxide is eventually broken down into its components of two oxygens and one sulfur each, and that there is then an additional process which is not yet understood, by which at least some fraction of those particles end up with about 10 percent the velocity of light just inside of Io's orbit.

The other science thing which I wanted to report has to do with what we are seeing on Voyager 2 now, in the case of atmospheric studies. As you know, Voyager 2 has already started our observatory phase. We are imaging the planet every two hours, as we did with Voyager 1, and there have been a number of changes in the atmosphere since we looked at it with Voyager 1 during the observatory phase.

The small inset in the center is, in fact, the Voyager 1 image of Jupiter showing the great red spot and, up on the left, is the side of Jupiter which now has the great red spot. It turns out the great red spot has drifted with respect to System 3.

System 3, as you may recall, is the coordinate system which is locked to the magnetic field and, therefore, locked to the deeper interior of the planet. And the great red spot has, in fact, drifted to the west. In fact, one can see, if one looks in some detail, that the relative position, for instance, of the turbulence which one sees here, there is a source of a lot of material which, essentially, provides the tracers which allows one to image the turbulence which is going on here.

If you look on this image, you will see that, in fact, the turbulence and the great red spot have separated. The source of the material which makes this turbulence apparent has shifted to the east, or the great red spot has shifted to the west.

And, in fact, as we go around the limb of the planet a ways, we find that the source of material which allows one to see the turbulence is now, if you like, around the limb from the great red spot, so that the great red spot and its turbulence source, which were apparently at the same System 3 longitude, essentially, have moved in opposite directions and now no longer appear on the same side of the planet.

The other thing, of course, one can see that it is particular -- here, one has these brown spots which, as you may remember, are clockwise anticyclones. You will notice that they are not here in this image. They are on Jupiter; they just happen to be, again, on the other side from the great red spot.

Another thing you may notice is that these white ovals -- there are three of these. They came into existence about 40 years ago when a white zone of clouds, essentially, broke into three pieces, and it has been contracting ever since into these three white ovals, which are more or less equally spaced -- not exactly -- around the planet.

And you can see that, in the case of Voyager 1, two of the three white spots are apparent here. There is a white cloud in between them. And now we see that this white spot, in fact, again, has -- well, in fact, the great red spot has actually moved in this direction, and this is the same white spot as the white oval as was apparent in Voyager 1.

And, of course, that changes the characteristic, some of the characteristics, that one sees around the great red spot, itself; there is no longer a white cloud deck immediately below it and, therefore, there is some change in aspect.

So, even in this small time span of about three or four months between Voyager 1 and Voyager 2, it is clear that there has been a continued evolution of the gross features of the Jovian weather system and, clearly, Voyager 2 will then provide an extended time base for the dynamic studies which are presently under way with the Voyager 1 data set.

Okay. I think that those are the two things in the science area that I wanted to mention. In terms of status, Voyager 2 instruments, basically, all of the instruments presently functional, normally functional. There are two where we have changed their operation to a certain extent.

In the case of the photopolarimeter, as in the case of Voyager 1, we will be operating that instrument only as a color photometer. In other words, we will not be operating the polarization wheel, so we will not get polarization measurements with the Voyager 2 photopolaremeter, only color photometry.

In the case of the infrared instrument, we have put it -- it is basically running at a somewhat warm condition. It does have a slow drift in its alignment and, of course, we are talking about alignments which are fractions of the wavelength of light over a period of time when it is at its operating temperature. So, we are presently running it warm, and we will switch it into its cold operating mode on June 20th, and there is -- in fact, this is a standard procedure we have adopted now, and there is certainly every reason to expect that that instrument will perform quite well for the close approach for Jupiter, and you have heard some of the results this morning, in fact, from the Voyager 1 instrument.

In terms of what is new and what kinds of new and different things we might expect on Voyager 2, first of all in terms of the satellite encounters, on Voyager 1, as you recall, our satellite encounters were all after our closest approach to Jupiter. That means that we saw one particular face.

With Voyager 2, by design, we are encountering both Ganymede and Callisto before closest approach to Jupiter, and that allows us to look at the opposite faces at about the same high resolution as we did on Voyager 1, but the opposite faces.

Also, we tended to go over the north polar regions on Voyager 1. On Voyager 2 we will have a much better look at the south polar regions on those two objects. So, we will be looking at some new real estate on Ganymede and Callisto, and we do certainly know that the brightness of the different faces of those two objects is different, so one may well have still a few surprises left there.

In the case of Europa, of course, we did not get as close to Europa on Voyager 1 as we did the other three and, as a result, again, by design, Voyager 2 is coming much closer to Europa. Our resolution, our best resolution, will be on the order of 4 kilometers per line pair, which is very similar to the kinds of resolution that we achieved on Ganymede and Callisto on Voyager 1, and that should allow us to have a much better idea as to what the long color streaks are that show up in Europa, whether those, indeed, are cracks in the surface, and whether or not we have indication of significant crustal stresses which could well be responsible for cracks, if that is what they are.

So, come July 9, we should have really a good look at Europa.

We have also -- you may also remember we have several occultation experiments where we look back -- where we observed the radio frequency signal as the spacecraft goes behind Jupiter. Our Voyager 1 passage was near the equator, Voyager 2 will make a passage, if you like, as viewed from earth, nearer the south pole, so we will be able to probe more of the polar atmosphere with our radio occultation experiment.

There are several changes we've made to the sequence. All the things I've discussed so far are more or less trajectory things which we designed several years ago. We have also, in the last several months, gone back and tried to make some modifications to our preplanned sequences. For instance, we are going to put in a 10-hour sequence of observations of Io's volcanic activity where we will be imaging every few minutes, taking an image every few minutes.

And it turns out the aspect that Io presents to the spacecraft at that time is that one particular volcanic region which was observed on Voyager 2 will more or less continue to be in the field of view for that entire period of time, so it should be possible to get some indication of the nature and the time scale of any variation in volcanic activity associated with the plumes, and also associated with some of these bluer regions which Larry mentioned this morning.

We have also modified our sequences so that the ultraviolet investigation will spend a great deal more time investigating the emission from the torus, itself.

On Voyager 1, since we didn't know exactly where the best place to look was, we essentially spent our time scanning the entire system, from Callisto's orbit on the one side, out to Callisto's orbit on the other side.

On Voyager 2, we spend most of the time we have right in around Io's orbit where we know there is a very intense ultraviolet emission, and it will allow us to, again, assess the variability, on a short time scale, of the processes that are going on, presumably related to the combination of Io activity and the magnetospheric processes which will cause a change in that auroral intensity, in the torus intensity.

As I think has already been mentioned, we intend to take more images of the dark side of the planet in order to assess the extent of the auroral radiation and the visible wavelengths, and also to be able to get a better idea of the distribution of lightning in the planetary atmosphere. We have a very tiny fraction of the planet captured in the Voyager 1 image, which you have all seen.

We are also planning to take more images of the ring. As you know, the one image we took on Voyager was carefully designed to be exactly at ring plane crossing. We will still do that again on Voyager 2, but we will also try to catch the ring when it is slightly open, so that we can have some idea of how far in the material extends.

All we know now is how far out it extends, so we have some additional images planned with the ring slightly open, both as we go in through the ring plane and as we come back out through the ring plane. So, hopefully, we will be able to have a better idea of whether the ring is like a Saturn's ring, which means it has a rather broad radial extent inward from the outer edge, or whether it is more like a Uranus' ring, which would have a very limited radial extent and it would be more of a ribbon around the planet.

I think that those are the major changes that we have made. We have also been adding some additional measurements for the plasmawave instrument so it can, hopefully, detect more lightning bolts, although it is important to recognize that we will not be flying through the torus on Voyager 2, and that may make it more difficult to detect the whistlers which Fred reported on Voyager 1.

Thank you.

MR. MC ROBERTS: I wonder if the investigators would come up and we will be open for Q and A. Okay. We're open for questions.

QUESTION: Larry, how many vents do you identify now? Do you know anything about the duration and sequence of any of the venting, how long one of them goes on, and how periodically they come on?

DR. SODERBLOM: Well, we have observed something like, I think it was nine at one time and now it is back to 8. I think 8 is the number now, and see each of these perhaps on the average of four times.

So, we have something on the order of 30 observations. In each case, the plume is fully developed. In other words, it's like a continuous lawn sprinkler just standing there going off. And that means that they are not in the process of either developing or collapsing.

And since it takes about ten minutes to become fully developed -- in other words, for the material to rise to the highest altitude and fall back to the surface. That means that the plume, each of those plumes, had been going on for ten minutes.

So, that means we have something of the order of 300 minutes of duration, which suggests, statistically, that they have to be active for several hours, physically.

Now, one I did show you, the one referred to as the "Tarantula", in the earlier image in which we looked directly down on that vent, we did not see the very dark pattern. So, that suggests a variability maybe on the order of days or less, but longer than hours.

MR. MC ROBERTS: Anyone else have a question?

QUESTION: Dr. Pearl, is there anything in the IRIS coverage that gives you an idea of the areal extent of the SO2 across the surface? Is there any way to read that out and see how far it travels from a given plume?

MR. PEARL: Well, our special resolution is not nearly as good as the imaging resolution. Our footprint is about 60 percent of the full narrow angle imaging frame. And the signature which I showed in the slide for SO2 is a region of the spectrum where we have, generally, very low signal.

It was high over the hot region simply because it was hotter than normal. Consequently, it will probably be very difficult to elaborate just what the distribution might be.

QUESTION: How many bluish areas have you seen?

DR. SODERBLOM: Well, we've only seen one where we have several images which we can demonstrate clearly that it is transient. But I'm convinced, having coupled the morphology and appearance of that one to the others on the disc, that we are seeing 30 or 40 at least.

It would be interesting to look to see if the IRIS instrument picks up any anomalies in the regions where those things are very dense.

QUESTION: Dr. Ness, is it odd that the northern auroral cap, or magnetic cap, or whatever you call it, is as eccentric as it is? It seems to me that there's been some work in the last few years of the earth's northern auroral region suggesting that they are, (a), eccentric and, (b), not lined eccentric to both planets' rotation axis and magnetic axis.

DR. NESS: Not true. The situation in the case of the earth is that it is coaxial with both the magnetic axis and the rotation axis.

QUESTION: But they aren't coaxial.

DR. NESS: No, they aren't, but the auroral zone circles around both of them. What we do observe on the earth is that the auroral zone on the day side, as measured by particle precipitation, is at a slightly higher latitude of 72 degrees when compared to the night side where the latitude drops it down to about 65 degrees.

So, essentially, the auroral zone is fixed in space and the earth rotates under it, in the case of the terrestrial auroral zone. On Jupiter, we believe the situation is quite different -- that is, the auroral zone is carried around with Jupiter because of the strong magnetic field and because it is so eccentric. So, the auroral zone, instead of being roughly stationary in space -- although appearing to vary, as it is on the earth -- will, in fact, vary considerably to a viewer outside the Jovian system. It will rock back and forth.

Because it extends down to 60 degrees latitude to about 80 degrees latitude, there will be periods of time in which, depending upon where one is observing, the auroral zone, in fact, should not be visible. It will be hidden by the planet.

MR. MC ROBERTS: Are there any other questions?

QUESTION: Dr. Scarf, at some point shortly after the encounter, I recall you mentioning that some of the, I guess, whistlers -- I was going to say "spirits", but maybe it was whistlers that had been detected -- were right near the time of that flux tube crossing, and others were not, and you were thinking about the possibility that maybe, for some mechanism I can't imagine, Io might be a likely source.

DR. SCARF: Well, I certainly was concerned about it because Io is so much closer to Voyager than the atmosphere of Jupiter, and also as I mentioned here but perhaps didn't mention as clearly as I might, all of these that we have detected so far have been in the torus region, the Io torus region, inbound and outbound.

I think I am much more convinced now than I was at the time we talked about this, that they are coming from the atmosphere, because the analysis that I told you we would do has been done.

We have compared the travel times, and the shapes, and seen if we can explain all of the characteristics by assuming they come from the atmosphere. In fact, they not only all appear to come from the atmosphere, but from the northern hemisphere. And we can explain the difference in the dispersions that we see on the inbound passage of the torus and on the outbound, by considering the difference in where the spacecraft was with respect to the torus.

QUESTION: On the lightning, can you tell from how many you detected, over what period of time, to estimate the frequency of the lightning? What is your best shot right now?

DR. SCARF: I really hate to say a number at this point. We have a very irregular data set because the waveform data, the high rate data that we are getting here is actually coming in spurts.

In order for us to get some of this data, they have to stop the processing of the imaging. This is not an easy thing to do. So, we don't have a uniform distribution yet. We will be getting it soon.

QUESTION: I get the impression that the flux tube is turning out to be rather different from what was expected, particularly in terms of the electrical energy. If Voyager had gone through the flux tube, would it's experience have been any different?

DR. SCARF: Well, we discussed this as we were coming in. Norman will have a comment in a moment, but one of the things that I think we weren't prepared for was the very dense plasma in the torus. And without any other consideration of targeting, that already suggests that the interaction between Io and the ionisphere of Jupiter has to be modified because of this very dense plasma around the torus.

Maybe Norman would like to take over at this point.

DR. NESS: If we had gone through the region in which the electrical currents flow, unquestionably, we would have seen drastically different processes in action.

We didn't pass very far from them. We were only about 5- to 6,000 kilometers, but those large currents which flow would, unquestionably, have distorted the local plasma characteristics, energetic particles.

We probably would have had a chance to see the energetic particles which had been predicted to be accelerated by this interaction process. To the best of my knowledge, such accelerated particles have not yet been reported.

When you have particles accelerated far above the velocities of the adjacent environment, certain instabilities can arise generating large amplitude noise which would have been detected by the plasma science, plasma wave experiment and by the energetic particle detectors.

Noise in the nature of turbulence, large amplitude fluctuations, this was not observed. The parameters were smoothly varied. We did not pass through the current carrying region, and we do not believe we passed through the Io flux tube, itself.

QUESTION: Could you have damaged the spacecraft had you passed through one of those regions?

DR. NESS: I don't believe so, but I can't be sure, because I don't know the nature of the charged particle environment that we would have enjoyed at that time.

QUESTION: From a charging standpoint, was that any sort of design constraint on the spacecraft, like an active potential surface or something, for the reasons of the flux tube?

DR. NESS: Not especially for the flux tube. Those considerations were very important in the design of the spacecraft generally simply because of the intense radiation belts and intense radiation environment, but not especially because of the flux tube.

QUESTION: Dr. Pearl, are there any infrared readings on the bluish areas Dr. Soderblom spoke about?

DR. PEARL: At this point, I don't know. I don't have the exact positions of those features, and I will have to check that.

QUESTION: The black and white photo that you showed at one point had a, if I didn't know what it was, a remarkably

Martian-looking, fluvial-looking, so on, channel at the bottom, half the width of the frame, all the way down the picture. Is that a fluvial-looking feature to you?

DR. SODERBLOM: Fluvial-looking feature. The black and white near the terminator, filtered picture?

QUESTION: Yes.

DR. SODERBLOM: What you see there is a series of cliff scarps, and there is a couple of features which are related to faulting in there, but nothing I saw that was particularly sinuous. There are some peculiar things in there which are these multiple layers that appear to be eroded at their escarpments in that frame, but I don't recall --

QUESTION: Why don't we show the slide.

DR. SODERBLOM: Sure. Back up about --

(Whereupon, the slide was shown.)

QUESTION: While he's looking, how many degrees west had the red spot drifted in System 3 and in what period of time, and is that an atypical thing for it to do?

DR. STONE: No.

QUESTION: What defines zero --

DR. STONE: Well, System 3, as I said, it's a coordinate system which rotates with the magnetic field and, presumably, therefore, is an important system tied deeper in the atmosphere, and I don't recall exactly where System 3 of zero is.

It is not unusual for the great red spot to drift, no, and I guess I should point out that the discussion which I gave was really information I got from Rita Beebe who is on the Imaging Team.

I can give you some numbers here. The great red spot is drifting at about 2.6 degrees per day -- these are from Rita Beebe -- that is in the westward direction, while the -- for instance, the white ovals are moving in the opposite direction, eastward, at 3.5 degrees per day.

And so, since it has been on the order of three to four months between the images I showed, of course, that means there is some reasonable longitudinal separation of those particular features. But, no, it is not unusual for these features to drift in System 3.

DR. NESS: In fact, they are supposed to because there the atmosphere, that is moving relative to, essentially, the surface of the planet. System 3 is defined by the magnetic field which is rooted to the interior. Systems 1 and 2 have to do with the motion of the surface, as seen by an observor outside.

And if the atmosphere has any coherent longitudinal azimuthal motion, you expect there to be a drift.

MR. MC ROBERTS: Someone else -- Larry Soderblom wants to answer that question.

Larry?

DR. SODERBLOM: Is this what you're referring to, John?

That's an artifact. This is an albedo boundary from the bright region and dark region, and the computer has filtered this to try to remove the regional variations to bring out the detail.

Remember, Mariner 9 pictures of the south polar cap had more filter along the ice produced a black-white boundary. It's exactly the same process.

But one thing I did want to mention rather briefly, these layers, see the multiple layers, and off of the escarpments you see outliners, isolated patches of the material that are at the same level as these scarps but detached from them.

The only process that we can think of to create this is some sort of stripping process that strips the surface. And the only place that these particular kinds of erosional escarpments occur in this, so far, is near the south pole.

And, as a matter of fact, remember when the auroral image pointed out the series of peculiar looking things near the south pole at one time. These are they. And perhaps some sort of a polar deposit, a polar vault deposit would be the most likely explanation for the erosion question.

QUESTION: In the straight stride further up the picture, are they all positive --

DR. SODERBLOM: These kinds of things are potential fractures that cut down through. As a matter of fact, here is a feature that is very common; in tectonics it's called a "graven", and it's due to the surface trying to increase its total area. In other words, the surface is being torn apart, so wedge-shaped fault blocks develop in order to allow the surface to expand.

MR. MC ROBERTS: Okay. Are there any other questions?

(No response.)

MR. MC ROBERTS: No other questions. John, why don't you get him afterwards. I think you're about the only one that's left.

We will end the press conference now.

Thank you very much.

(Whereupon, at 12:00 noon, the NASA news conference on the Voyager 2-Jupiter encounter was concluded.)