NWX NASA GSFC AUDI CORE

Moderator: Nancy Jones
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Coordinator: Welcome and thank you for standing by. At this time all participants are in a listen only mode. At the end of the presentation we will conduct a question and answer session. To ask a question please press star 1. Today's conference is being recorded.

If you have any objections you may disconnect at this time. Now I will turn the meeting over to Ms. Nancy Jones. Ma'am, you may begin.

Nancy Jones: Thank you. Good afternoon. My name is Nancy Jones from the Office of Public Affairs at the NASA Goddard Space Flight Center in Greenbelt, Maryland. I would like to welcome you to this NASA media teleconference featuring new results from NASA's lunar reconnaissance orbiter mission.

All supporting materials to accompany today's briefing have been posted online at www.NASA.gov/LRO for viewing. If you are unable to see the documents please try refreshing your browser.

Our panel for today's briefing includes Michael Wargo, Chief Lunar Scientist from the Exploration Systems Mission Directorate at NASA headquarters in

Washington, DC; Thomas Watters, Senior Scientist from the Center for Earth and Planetary Studies at Smithsonian's National Air and Space Museum in Washington, DC; and John Keller, Lunar Reconnaissance Orbiter Deputy Project Scientist at NASA Goddard.

We will now begin today's discussion with Mike Wargo. Mike?

Michael Wargo: Yeah, thanks Nancy. Good afternoon everyone and thanks for being able to join us here today. The lunar reconnaissance orbiter mission has been going very smoothly since our launch last year in June.

And we're here today to tell you about one of our most recent and exciting discoveries that's just about to be published this week in the Journal of Science.

The cooling of the moon's interior has been causing it to shrink, not by a lot but enough that the shrinkage might be expected to change the surface of the moon. And today we're here to tell you about the evidence that we've found of that change.

The evidence comes from carefully examining those amazing high resolution images that you've seen come back from the lunar reconnaissance camera on LRO since we've gone into orbit last year.

But before giving you the scientific details let me give you a little bit of background on - for this briefing.

This important scientific discovery is coming from a spacecraft in a mission whose primary purpose from the very beginning was to measure those kinds of things that NASA is going to need to be able to continue to explore the moon and do it both safely and effectively.

Things like creating high resolution maps, identifying hazards, locating potential resources and measuring the space radiation environment.

We knew at the time that we were developing the mission that we couldn't make these kinds of high priority exploration measurements without measuring the best that the scientific community has to offer, and that includes both the scientists as well as the instruments that the scientists develop to make those measurements.

We also knew that even though science wasn't the primary focus of this mission that these remarkable instruments that we have onboard would be finding out things about the moon that would give us new insight into the moon's origin and evolution.

And really nothing expresses this kind of interplay between exploration and science better than the words that you'll find on the logo of the lunar reconnaissance orbiter camera. Exploration enables science and science enables exploration.

This discovery is one that demonstrates the contribution that the lunar reconnaissance orbiter mission is making to science. And now to give you more details about this scientific discovery, here's Tom Watters.

Thomas Watters: Thanks Mike. It's a pleasure to be here. With the cameras aboard the lunar reconnaissance orbiter we have the first evidence of a globally distributed population of thrust faults that indicates the moon has recently contracted and may still be shrinking.

This is exciting because our nearest celestial body might still be tectonically active today. We knew from the highest resolution photograph taken during the Apollo mission that land forms called low based scarps were found in some areas of the lunar equatorial zone.

Low based scarps are land forms that look somewhat like a stair step in the landscape. They're formed by thrust faults. As illustrated in image one, a thrust fault is kind of what it sounds like. It's a break in the surface materials formed when the lunar crust is pushed together.

A crust of material is pushed or thrust upward along the fault forming a scarp. Because the Apollo photograph covered only a relatively small area of the lunar surface we really didn't know how widely distributed low based scarps are on the moon.

The Lee-Lincoln scarp shown in image two is one of the previously known low based scarps. It's the land form running across the image on the left.

The topographic map derived from the lunar reconnaissance orbiter camera stereo images shows the Lee-Lincoln scarp extends across the Taurus Littrow valley and upslope into the highlands of North Massif. The scarp is just west of the Apollo 17 landing site shown in the image by the arrow on the left.

Previously undetected low based scarps have been revealed in the lunar reconnaissance orbiter camera images. One of these shown in image three is Gregory scarp. Here shown by the arrows the thrust fault pushed crusted material up the wall of a farside impact crater.

The spatial distribution of the low based scarps is shown in image four. Previously known scarps are shown by the black dots and the white dots show the locations of newly discovered low based scarps. Half of these newly discovered low based scarps are actually at high lunar latitudes.

And some are actually found near the lunar poles. The discovery of the previously unknown low based scarps means that thrust faults occur across the lunar globe and are most likely caused by global contraction or shrinking of the moon.

The moon shrinking is due to cooling of the lunar interior. As the interior cools it contracts causing the moon to shrink. Although the low based scarps indicate contraction the moon has not shrunk by much over the recent past.

We estimate the total radial contraction, that is the distance between the moon's center and its surface, that is expressed by the thrust fault scarps, is only 100 meters or about the length of a football field. Another remarkable detail about the low based scarps is their apparent age.

They appear to be very young. One way to estimate the age of the fault scarps is by cross cutting relations with impact craters. As shown in image five, some fault scarps cut across small diameter impact craters indicated by the arrows and shown in the outset box.

Small impact craters do not survive very long because they are destroyed more quickly by other impacts on the moon, thus low based scarps must be relatively young. But even more convincing evidence of a young age is the lack of large diameter superimposed impact craters.

Also the low based scarps are very pristine and undegraded looking. The young age of the fault scarps indicates that the moon has contracted very recently, well within the last 800 million years and possibly much more recently.

These young fault scarps do not preclude the likelihood of a much earlier contraction of the moon. But evidence for this earlier contraction has yet to be recognized. To summarize, I think there is a general impression that the moon is geologically dead.

That everything important in the geologic history of the moon happened billions of years ago. One of the most exciting results of this research is that this is just not the case. The moon may still be geologically and tectonically active and still shrinking today. Now I'd like to introduce John Keller.

John Keller: Thank you Tom. I just wanted to add a few words about the mission, to provide some context as to how and why these results were enabled. First, these results highlight the importance of global measurements for understanding global processes.

The lunar reconnaissance orbiter which is managed by Goddard Space Flight Center is a spacecraft that is very well optimized for making these kinds of measurements. The images that Tom has just presented were taken by the narrow angle cameras or NACs, onboard the LRO spacecraft.

And the NAC cameras in turn are part of the instrument suite that was provided by the lunar reconnaissance camera team led out of the University of Arizona, that Professor Mark Robinson is a principal investigator.

In turn the LROC instrument is one of seven onboard the spacecraft, most of which are making global mapping measurements as well. The NAC cameras are a pair of imagers that provide 50 centimeters per pixel resolution.

And the two cameras are generally operated simultaneously to provide side by side image pairs that are 25 kilometers in length and 5 kilometers wide.

Over the course of the one year mission the LROC team will have imaged roughly 10% of the moon at this resolution for a combined area larger than the total land area of the six largest states in the US, that's Alaska through Arizona.

The LRO mission is continuing to make these observations and as more tectonic features are uncovered and mapped the LROC science team will continue to refine our understanding of the tectonic history of the moon.

The first year of the LRO mission was spent as part of NASA's exploration systems mission directorate. But this September responsibility for the mission will be transitioned over to the science mission directorate where we will begin a two year extended mission.

Over this period we will continue to make the kind of observations that Tom has just described and other observations that will help refine our understanding of the forces, processes that shaped our moon. So with those comments I'll turn it back over to Mike for a summary.

Michael Wargo: Thanks a lot John. Well before LRO's launch it was pretty common for a lot of folks including many scientists, to think of the moon as a dead, unchanging planet, just like Tom was - and John were saying.

But now after only a year of observations from LRO we're finding that to the contrary, the moon is a truly dynamic planet. Who would have thought that tectonic processes might still be operating even today?

Where once we thought that changes occurred over billions of years we're now finding that some of these changes might be occurring over much, much shorter time periods and may even be occurring even as we're talking now.

But as the case in many significant discoveries this really marks only the beginning of our understanding of this dynamic nature of the moon and certainly is not an end.

So you really have to be able to stay tuned because we'll be having much more information about that as we proceed into the science portion of the mission starting in mid September. So now with that let me turn things back over to Nancy.

Nancy Jones: Thank you Mike. Operator, we're now ready to take questions.

Coordinator: Thank you. We will now begin the question and answer session. If you would like to ask a question please press star 1. You'll be prompted to record your name. To withdraw your question you may press star 2. Once again, if you would like to ask a question please press star 1.

One moment please for our first question. And our first question is from Kenneth Chang from New York Times. Your line is now open.

Kenneth Chang: Hi. Thanks for taking my question. During the Apollo mission the seismometers recorded numerous moon quakes. I was wondering if they correspond at all with these scarps.

Thomas Watters: That's an excellent question. This is Tom Watters. I'll take that one at least to start.

That really is one of the really tantalizing possibilities that discovering these very young thrust fault scarps really makes possible - this connection between seismic activity that was detected by the Apollo seismograph and these very young scarps.

About 30 or so of the moon quakes that were recorded are relatively shallow quakes. And - but one of the things we're looking into is exactly that possibility is if there is any - if there's any spatial correlation between these known moon quakes and any of the low based scarps.

But I think it is definitely certainly a possibility.

Kenneth Chang: Okay, thank you.

Coordinator: Our next question is from David Perlman of San Francisco Chronicle. Your line is now open.

David Perlman: Yeah. First of all, thanks a lot for taking my call. Ken Chang mentioned - asked the question and which Apollo mission was the - was the seismograph detecting those moon quakes?

Thomas Watters: Well there were actually four seismic stations that were located on the moon by - so one - one was located in each of four of those. I have to go back - Mike do you remember which of the four - I think it was 14 through 17.

Michael Wargo: I believe that's the case. And when you look at how they were arranged on the surface it was almost in the form of a triangle where along one of the baselines we had an additional seismic station.

David Perlman: And does the location of those seismic stations coincide in any way, near or in some fashion its ability there - the seismograph's ability to detect moon quakes as you call them, near the low based scarps?

Thomas Watters: Yeah. Just to go back - I just checked this - a source. The Apollo stations were Apollo 12, 14, 15 and 16.

David Perlman: Okay.

Thomas Watters: Okay, to get to your - to your question it is a colleague who is not connected directly with the lunar reconnaissance orbiter mission, her name is (Katherine Johnson), has actually been working to reprocess the lunar seismic data to - using modern seismic processing tools to try to better - with less - or, you know, more certainty determine the actual locations of the epicenters.

And it's a pretty tough job because the signals, the noise in the Apollo seismic data was not great. At this stage we have not made any definitive connections between a given seismic event and the location of one of the low based scarps. But it is one of the areas that we intend to do more work in.

David Perlman: Okay, thank you. And - but the real question I wanted to ask was...

Thomas Watters: Sorry.

David Perlman: ...in the course of LRO's flight over the site where - where the (LCROSS) mission did its work, in that area were any of these low based scarps detected and any of them with any recent crossing of the - of craters or anything like that?

Thomas Watters: I can answer that one of the low based scarps is actually on the wall of (Cabreas). Now it's - now I'm not sure if you're suggesting a connection between the (LCROSS) impact and - and the scarp itself but...

David Perlman: No, I wasn't thinking that.

Thomas Watters: Okay. All right.

David Perlman: I mean the moon created a scarp? No, not at all. I just...

Thomas Watters: No.

David Perlman: ...was curious to know in that area because there is, you know, there's a kind of story connection between the two, not necessarily...

Thomas Watters: Oh, I see.

David Perlman: Yes.

Thomas Watters: Well then the answer is absolutely yes. There is a - there is actually a low based scarp that is very close or reasonably - I wouldn't say very close but reasonably close to that - to that impact site.

David Perlman: Okay, great. Thank you.

Thomas Watters: Sure.

Coordinator: Our next question is from David Shiga of New Scientist Magazine. Your line is now open.

David Shiga: Thanks. I guess I'm wondering whether this indicates more cooling in the contraction recently than we would expect from theory or if this sort of fits what we would expect but just hadn't observed until now.

Thomas Watters: It really depends on your initial starting temperature for the moon. Thermal history models do predict that the moon should still be cooling even at present.

I think what's really exciting again about these results, are that we're seeing the first sort of physical manifestation of cooling and contraction of the moon that really indicates yes, indeed it is actually still and must be cooling in the interior, from the interior.

David Shiga: Okay, thank you.

Coordinator: Our next question is from Peter Spotts of a Christian Science Monitor. Your line is now open.

Peter Spotts: Oh. Thank you very much for doing this. I'm going to really betray my ignorance here but when we're talking about heat presumably that's left over from the big smack that formed the moon. And I wonder if one of you could kind of extend the surprise for this.

Because it struck me that only what a year ago at that, we were beginning to talk about a hydrological cycle on the moon too. So we're looking at an object that not only is, you know, potentially tectonically active today but has its own version of a hydrological cycle. That was a surprise.

Michael Wargo: Well yeah, that's one of these, you know, we've used the term in the past this isn't your grandfather's moon anymore.

And, you know, when you look at the new information we've garnered with a number of different missions to the moon, not just LRO, and over only the last year, we're now talking about the moon in a completely different way.

It was thought to be, you know, dead and unchanging were pretty common words to describe it. And now you have this dynamism. You know, the work that Tom's done, you know, we're talking about the recent past geologically.

But the kind of changes that we're seeing with respect to the hydrology as we've called it, that occurs on at least at surface levels, on weekly and monthly kind of - kind of time scales which is certainly not geologic.

So we have a dynamism associated with activities on the moon that's just unlike anything that folks were thinking of, certainly a year ago.

Peter Spotts: Okay.

Coordinator: Our next question is from Paul Hoversten of Air and Space Magazine. Your line is now open.

Paul Hoversten: Yeah, thank you. A quick housekeeping question. Who was that last speaker please?

Michael Wargo: That - I'm Michael Wargo.

Paul Hoversten: Okay. Thanks Mike.

Michael Wargo: Yep.

Paul Hoversten: I have a question - I guess it's for Tom. The shrinkage that you're seeing is that - is that something that was very gradual or is there any evidence that it could have been much more sudden?

Thomas Watters: That's a really good question. Again, from using the cross cutting relations between these very small diameter craters and the fault scarps themselves we were able to at least fix a maximum age that these scarps can't be any older than about 800 million to a billion years old.

So from that what you could say is that the evidence that we have for this 100 meters of this radius change has occurred no more or over a period no longer than the last billion years.

But the fact that these scarps are so young in appearance really suggests that this 100 meters worth of radius change could have happened again, much more recently and just how recently we can't really tell.

So what one of the - one of the really exciting follow on studies that we intend to do is to look at those Apollo era photographs of the low based scarps and compare those with images taken by the lunar reconnaissance orbiter camera and look for any indication of change on these scarps that would give us some idea of whether they're still currently active.

And that might help us figure out also how quickly these fault structures have actually grown.

Paul Hoversten: Okay. And then just a follow up. Is your expectation then that the shrinkage would continue on indefinitely I suppose? Or is there some sort of solar event that could conceivably get the moon back into its shape?

Thomas Watters: Oh. No, I think the - I think any kind of an external influence from the sun in particular is unlikely. What is likely to happen is that the cool - that the moon will continue to cool.

That cooling will again, you know, over time diminish and so the contraction or shrinking that's coming from it will also -would also be expected to diminish with time.

Paul Hoversten: Then just what would be the final end state? Is there any way to predict that?

Thomas Watters: I mean I think you can - you can say that as a final end state the moon will eventually lose all of its internal heat and truly will then become geologically inactive except, you know, internally geologically inactive.

Paul Hoversten: Well I guess what I mean - how would it appear to a person - to a person looking up in the sky many, many, many years from now?

Thomas Watters: Oh, I see. No, yeah, the kind of radius change and shrinking that we're describing here is so small that you would never notice it even with - even from, you know, looking at - using telescopic observations.

You would never see the kind of small - small contraction amounts that we've estimated are expressed by these faults.

Paul Hoversten: Okay, thanks.

Thomas Watters: Sure.

Coordinator: Our next question is from Kelly Beatty at Sky and Telescope Magazine. Your line is now open.

Kelly Beatty: Hey, thanks very much. I want to follow on what David Shiga asked about if this was as much as you expected, more so or less so? I mean the moon was basically completely molten at one time.

I guess I'm puzzled why it is more widespread and why the manifestations aren't older like harking back to say the time when the (Mario) formed.

Thomas Watters: It's an excellent question. I'm going to throw in a comparison now from one of my other favorite celestial bodies, Mercury, which has also undergone contraction. We know that from the Mariner 10 Mission and now from the Messenger Mission.

Mercury, like the moon, also has low based scarps. But the low based scarps on Mercury are humongous compared to those on the moon. Instead of being several kilometers in length and typically tens of meters high like those we see on the moon.

Low based scarps on Mercury are hundreds of kilometers long. In fact we've discovered one that's almost 1000 kilometers in length. And they can be hundreds of meters in relief.

And many of them are over a kilometer or approaching 2 kilometers and really - that really indicates a large amount of contraction which likely is due to Mercury beginning at a much hotter initial temperature, probably hot enough to have melted the entire body.

I think one of the interesting results is that by looking at the moon and now again, this population of young small scale thrust faults, is that the moon couldn't have gone through that same sort of thermal evolution.

It just hasn't contracted by that amount because we would expect to see much larger thrust faults that have - would have survived since the period of heavy bombardment which is that time. Of course when the surface of the terrestrial planets were basically erased by, you know, saturation impact.

Is that answering your question?

Kelly Beatty: Well I guess. I think what you said right at the end is that this may place some new constraints on the magma ocean hypothesis.

Thomas Watters: That's true. That's true because this - the magma ocean thermal history models that the - have been developed for the magma ocean model predict much less contraction than those that are - that have an initial condition which would be hot enough to melt the entire moon.

Kelly Beatty: One quick follow up - would these show up in the (Cabreas) database?

Thomas Watters: That's an excellent question. I think the answer to that is yes, some of them should be detectable at the resolution of the (Cabreas) imaging.

Many of them may not be because some of these are so small, again we're talking about one - some of these that are again only 1 or 2 kilometers in length and maybe only meters high, that you really do need the narrow angle cameras on lunar reconnaissance orbiter to detect them.

And in fact again I think one of the exciting prospects to me is again, and I think as Mike mentioned we've - or John mentioned that we've really only imaged, you know, with the narrow angle cameras less than 10% of the surface of the moon.

As the mission continues and hopefully with even an extended mission, we hope to be able to generate a global 1 to 2 meter per pixel image map of the moon that will make it possible to detect and map all of the low based scarps on the moon.

Michael Wargo: Yeah, and let me make - this is Mike Wargo. Let me make an additional comment here. And that is that working together with both data sets I think is going to be really valuable.

Because even though the cameras (Cabreas) don't have as fine a resolution as the narrow angle camera on LRO, they may still be able to detect the presence of the low based scarps.

But that would then give a key to LRO to do a more precise targeting of those areas to look at them in even finer detail so that you can look at the - the nature of impacts in there near the scarps so that you can potentially do the dating more accurately.

So being able to use both sets of data I think is going to end up being valuable.

Thomas Watters: Yeah, I should...

Kelly Beatty: Thanks much.

Thomas Watters: Yeah, I should mention on top of that Mike, that in fact one of the low based scarps we did first detect - and one of the newly detected low based scarps was first detected in a (Cabreas) image mosaic that we then targeted, just as Mike said, we then targeted it to get better to look at it.

And in fact it was a low based scarp.

Kelly Beatty: Is it fair to characterize that then as the (Cabreas) investigators not realizing what it was?

Thomas Watters: I - I don't think I'm prepared to say...

Michael Wargo: Or they may not have been looking for it.

Thomas Watters: It may well be that's the case, that they just - they may not have been looking for it because these things are not features that are going to again, that the scale that we're talking, these features are not - they're land forms that are not going to jump out at you unless you are actually looking for them and you have sort of an eye and an idea of what you're looking for.

Kelly Beatty: Okay, thanks.

Thomas Watters: Sure.

Coordinator: Our next question is from Anne Walters of German Press Agency. Your line is now open.

Anne Walters: Hi. I was hoping you could explain a little bit more about what you can do moving forward to see if the cooling is still ongoing. You mentioned comparing the photos with Apollo era photos. Is there any other research that you would need to do to determine that?

Thomas Watters: I think that would be the most - the most direct way to determine if we still have any kind of tectonic activity going on if these thrust fault scarps are actually continuing to grow with the data set that we have. Of course it would be terrific to have additional instruments on the moon.

Seismographs would be a terrific addition and heat flow sensors would be a terrific addition in the future, that would help us to continue to determine and refine the - the sort of geologic evolution here that appears to be coming from the results of the study.

Anne Walters: Great. Thank you.

Thomas Watters: Sure.

Coordinator: Our next question is from David Perlman with San Francisco Chronicle. Your line is now open.

David Perlman: Thank you. And I really don't have a question but I am surprised that none of you identified yourselves at least at the early part of the questions. And this happens again and again. It's just a mild complaint. But it's very hard for people - reporters on a telephone to identify you all.

And I wish NASA folks would just coach you in how to tell who you are.

Thomas Watters: I apologize. I did that - you're right. I did that first and then I forgot to do it again.

David Perlman: Yeah, and I'm - we're not familiar with you, at least I'm not familiar with your voices. I don't live with Goddard and anyway, thanks for this very good press conference.

Michael Wargo: Tom's absolutely right. This isn't what we normally do for our day jobs. And we really should have done that.

For anyone who's still on the loop are there any things that we've said - and I'm Mike Wargo, I just broke the rule again, but are there any things that we've said that - where you weren't sure who was talking at the time?

And David you're absolutely right. We weren't real good about telling you who we were.

David Perlman: Well who was it who used the word humongous? I'm always looking for hot quotes.

Thomas Watters: Guilty. Tom Watters.

David Perlman: Oh okay. Well now I can sort of link your voice with some of the words I wasn't sure of. Oh, go ahead. This will all be I gather, online pretty soon anyway. I'll follow - figure out who was who from that. Thanks.

Thomas Watters: Well Mike has such a distinctive voice.

David Perlman: And you didn't identify yourself.

Michael Wargo: Guilty.

Coordinator: Our next question is from Leo Enright at - from Irish Television. Your line is now open.

Leo Enright: Thanks very much. I'm not picking up on David's point when I say that somebody, I can't remember who, mentioned seismology and the Apollo seismometers. I'm just wondering - the Apollo 17 (unintelligible) drove over one of these things.

And I'm just wondering if there is historic data that you can go back and look at that would help there. As I recall they also had a heat flow experiment very close to one of these scarps. So is there something that can come out of that?

And it's sticking to that sort of historic question, is there stuff potentially from the new reconstituted lunar orbiter stuff that might increase your historic database?

Thomas Watters: That's an excellent series of questions. And if I missed one - this is Tom Watters, I'm sorry, answering start.

First you're absolutely correct and I didn't have time to mention it but since you've asked the question or raised it, the Lee-Lincoln scarp that is in the - I think it's in the second of the images, was very close to the Apollo 17 landing site.

And it is - it has the distinction of being the only extra terrestrial fault scarp that has ever been traversed and studied in the field by humans.

So they did in fact take many excellent photographs from the surface which I actually used those photographs in my study of the Lee-Lincoln scarp and others have as well, not just myself.

But it's a - it's a wonderful data set that's available online that you can actually see that - as I described that stair step in the landscape, the Lee-Lincoln scarp fits that perfectly. So yes, it definitely is - the Apollo 17 mission (unintelligible) traverse of that scarp was very valuable.

In fact again, one of my favorite descriptions going back and looking at that was that they tried to drive the lunar excursion vehicle up - straight up the scarp and the wheels actually started to slip because they were losing traction.

So they actually had to zigzag up to get the - zigzag on the scarp face to get up and over the scarp. So the second point I think you raised was about the heat flow experiment.

That's an excellent question and it's something that we've been talking about just briefly and I think we're going to probably follow up on. You had another question I know, was there another question that I missed there?

Michael Wargo: Yeah, it was...

Leo Enright: Yeah. The lunar orbiter - the lunar orbiter...

((Crosstalk))

Thomas Watters: Yeah, thank you. Yeah. Again in being brief here I didn't give due credit to lunar orbiter. Lunar orbiter did return some very high resolution images of the moon.

There are some - some lunar orbiter images that are comparable or close to comparable in resolution to these highest resolution images that were - or photographs that were taken by the panoramic cameras.

And actually one or two of the - at least two that I know of, of these low based scarps were actually first detected in the high resolution lunar orbiter images. And I have used those when we were going back and we were actually targeting the previously known scarps.

We did and continue to use lunar orbiter archival imaging to help in that process. I hope that answered the - your question.

Leo Enright: Yes. Thank you very much. Yes.

Coordinator: Our next question is from Kelly Beatty at Sky and Telescope Magazine. Your line is now open.

Kelly Beatty: Thanks again. To continue the who's on first, I think it was Mike Wargo who alluded to the fact that with the extension of this mission for another couple of years there's the possibility of getting this kind of resolution over the whole lunar surface.

And can you quantify just how long you have to keep doing what you're doing to get a global map?

Thomas Watters: I mentioned that I think. This is Tom Watters again. I mentioned that and Mike maybe able to speak to that. I think - I'll throw this out from my discussions with Mark Robinson who is the real expert on this, as the PI of the camera.

We have two more years in the SMD phase of the mission that I guess starts in September. I think we would need another year extended mission beyond that, to get close to producing this global 1 to 2 meter per pixel image map of the moon.

Is that consistent with what you know John and Mike?

John Keller: Yeah. This is John Keller. Yes, that's right. I understood that to get a 2 meter resolution global image of the moon it would take - it would require us going beyond the two years of our extended mission and LRO is capable of doing that.

We would end up parked in an orbit that has fairly low maintenance and that would allow us to continue.

Michael Wargo: Yeah. And the reason that that's at about 2 meters resolution rather than the half meter or 50 centimeter images that we're getting from the narrow angle camera now is that it was just what John Keller just indicated. This is Mike Wargo.

And that is that this parking orbit that we would be in this low energy orbit that allows you to continue for a long time, is an elliptical orbit that goes from about (30) kilometers altitude near the South Pole to a little over 200 kilometers altitude over the North Pole.

And of course the resolution that the camera has depends on what altitude you're at. We're at 50 centimeter resolution now at 50 kilometer orbit. But to stay in that orbit uses a lot of fuel.

So we wouldn't have enough fuel to stay in the orbit we have now, to get 50 centimeter resolution over the whole moon. But if we go into this low maintenance orbit which goes up to about 200 kilometers we'd end up with no worse than about 2 meters resolution over the whole moon.

Kelly Beatty: And so since one of the primary reasons for having LRO in the first place is to sort of assess landing sites for possible future human habitation or visits anyway, wouldn't this global - wouldn't completing a global map at 1 to 2 meters seem a reasonable thing to do just because?

Michael Wargo: Well I'm sure that's why Mark designed the camera the way that he did. It's Mike Wargo. Clearly having comprehensive data sets is going to be valuable to both exploration and science.

And we knew that we had a capable enough spacecraft that we could extend well beyond the one year of the exploration mission. And we're adding two more years for science measurements. And in principle the spacecraft and the instruments could go even longer than that.

But we do this step by step and that of course will then be evaluated again at the end of that upcoming two year time period. And we'll see at that time if the spacecraft is in the right condition, if we have the right fuel reserves and if we have the resources to be able to extend it again. Does that...

Kelly Beatty: Thank you.

Michael Wargo: We've only got two more years.

Coordinator: Our next question is from Kristen Minogue from Times Magazine. Your line is now open.

Kristen Minogue: Hello. Thank you for speaking to all of us. I was wondering back in track to the earth - to the moon's history. Since the shrinking right now is as you said, so gradual is there any evidence or thoughts that it was faster before or has it always been this rate?

Thomas Watters: Hi. This is Tom Watters again. That's a very good question. And we really don't know and can't determine at this point what actually the rate of contraction is likely to have been.

If we get lucky enough to - and if this is - the moon is still currently tectonically active and some of these faults are actually slowly developing there is a possibility that we might be able to get a number like that. But it would be very difficult.

Kristen Minogue: Okay. All right, thank you.

Thomas Watters: Sure.

Coordinator: Our next question is from David Shiga with New Sciences Magazine. Your line is now open.

David Shiga: Hi. Just a follow up on that. So the fact that you don't see these really large scarps like you do on Mercury does that tell you that there wasn't as much cooling as there was there? And does that in turn cast doubt on the giant impact formation idea for the moon?

Thomas Watters: Excellent question. Well first of all, it - I'll take the last part of it first. I - it really doesn't directly connect to the formation mechanism of the moon. It's really more a question of what that initial starting temperature of the early accreted moon was, if it was hot enough again, to melt the entire moon.

Or whether it was only hot enough to melt the exterior while the interior didn't melt initially. So of those two possibilities, of those two scenarios for the thermal evolution of the moon, our results are really much more consistent with a cooler initial starting temperature for the moon.

In other words, a starting temperature that did not allow the entire moon to melt. And so yes, compared with Mercury, a planet that likely did fully melt and then contract more, I think the moon has contracted by a small fraction of - or a fraction of the amount that we appear to see evidence for on Mercury.

David Shiga: I thought though that that giant impact idea that would have resulted in a completely molten moon to begin with or is that wrong?

Thomas Watters: Well I think it depends. I mean I'm not the - I'm not an expert in that area by any means. But I think it depends on again your starting conditions.

The debris cloud that would have been formed after the giant impact (heard) and then accreted, it really then depends on the dynamics of how the moon accreted from that debris cloud which is the combination of the impact or - and parts of the earth's crust and mantel.

Whether that was depleted in radioactive elements, you know, whether the dynamics of the accretion were such that it didn't induce enough heat for the moon to initially melt, I think is a really interesting area of - that needs further study and modeling.

David Shiga: Okay, thank you.

Thomas Watters: Sure. Did I identify myself? This is Tom Watters.

Coordinator: At this time if there are any - actually one moment. We have a question from Ken Kremer with Space Flight. Your line is now open.

Ken Kremer: Hi. Thanks very much. A very interesting press conference. I was wondering - you mentioned that the Apollo 17 astronauts drove over one of these scarps. Did they happen to take any samples?

Thomas Watters: Yes. They took many, many rock samples. It's an interesting question. I'd have to go back and look at - and to see if they actually did any sampling.

I don't believe they did any sampling across the scarp face itself but they certainly sampled - took many samples of the Taurus Littrow valley which is largely or wholly (mares) of fault.

Ken Kremer: Yeah. I meant specifically from the low base scarp. Yes.

Thomas Watters: That's an excellent question. I don't - I don't think I can answer that. I think my guess would be no. But I would not bet that they did not actually sample it. That's a very good question - something I'll go back and look at.

Ken Kremer: Because you could presumably get a lot of answers and many more questions from something like that.

Thomas Watters: Well it depends. The fault itself probably didn't alter the faults by very much. Because again these are - these are relatively small thrust fault structure.

So there really wouldn't - I wouldn't expect that there would be any kind of modification of the actual - of the faults themselves as they were being deformed. But it's still an interesting question.

Ken Kremer: Yeah. Yeah. Let me just ask you too about the 100 meters, how you came up with that number. Is it more than just based on the height of these scarps, an average height? Or how did you calculate it?

Thomas Watters: Yeah. It's determined by taking the - I mean to put it simply you're looking at the amount of shortening or contraction that is representative of a subset of the population of these scarps.

And then you take that and extrapolate it to the entire population and then extrapolate that to the amount of contraction that would have occurred in the moon itself.

So it's actually based at looking at specifically how much shortening and displacement has occurred on the faults that have created some of the scarps.

Ken Kremer: One last question, are there any - are the pictures perhaps from any of the Russian probes that would shine some light on this question for comparing.

Thomas Watters: This is Tom Watters again, very good question. I don't know the answer to that but it's certainly worth looking into. My guess is no, because I don't know of a case where those were close to one of the low based scarps but it's a good question.

Ken Kremer: Okay. Thank you very much.

Thomas Watters: Sure.

Coordinator: Our next question is from Paul Hoversten with Air and Space Magazine. Your line is now open.

Paul Hoversten: Yeah, thanks for taking my question. I guess for Tom again, over time as the moon continues to shrink do the models say anything about what we - what you might expect to see as far as the existing scarps? Would they grow? Or would you expect to see new scarps turning up all over the surface?

I mean what can we expect the moon to look like, a big cracked ball at some point?

Thomas Watters: No. It's a good question again. I think the - again the amount of contraction that we have estimated from the population of these small thrust fault scarps is such that you're really not going to expect a very large amount of new contraction on the moon.

In other words, we're not going to start developing thrust faults that will produce Mercury scale low based scarps.

I think another excellent question is if the moon is tectonically active today and these faults are still - some of them are still continuing to grow then yes, I think it would be certainly plausible that new thrust fault scarps could develop.

Paul Hoversten: So could the moon have like canyons at some point?

Thomas Watters: No. It's unlikely. Canyons are generally formed by the opposite sense of motion that formed these thrust faults. So canyons are usually formed by extension or pulling apart rather than contraction or pushing together.

So we wouldn't expect to see - to see canyons or (grobbin) as they're better described of any scale - of any large scale developing on the moon.

((Crosstalk))

Paul Hoversten: I'm just curious if you can point us to something on earth that we could sort of use for comparison's sake.

Thomas Watters: For a - for a low based scarp?

Paul Hoversten: Well for a - for a, you know, for something - for what it might be a large scarp in the future.

Thomas Watters: Oh, there are - there are analog structures not of the scale that we find on the moon, at least one that I'm familiar with, are more - are comparable to the large scale low based scarps found on Mercury and those you can find in Wyoming in the (foreland fold) and thrust belt in, you know, the Rocky Mountain (foreland fold) and thrust belt there are some examples.

Paul Hoversten: Okay, great. Thank you very much.

Thomas Watters: Sure.

Coordinator: At this time if there are any further questions you may press star 1 now. We have no further questions at this time.

Nancy Jones: Okay. Thank you Operator. And we'd like to thank those of you who have called in or listened online to today's briefing. We look forward to more exciting science results from the lunar reconnaissance orbiter mission. This concludes today's briefing. And have a great day.

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