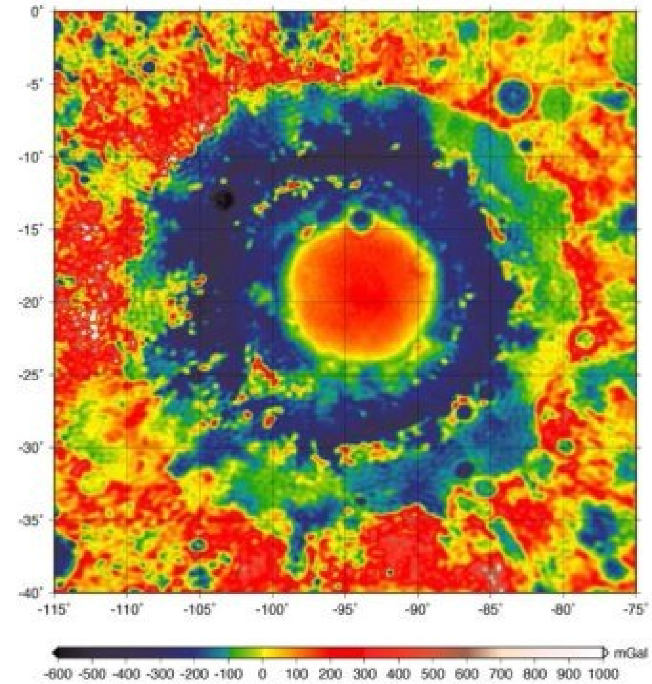
**GIANT IMPACTS ON MOON, EARTH AND MARS**

New results from NASA's Gravity Recovery and Interior Laboratory (GRAIL) mission are providing insights into the huge impacts that dominated the early history of Earth, Mars and Moon.

In two papers, published this week in the journal Science, researchers examine the origins of the Moon's giant Orientale impact basin. The research helps clarify how the formation of Orientale, approximately 3.8 billion years ago, affected its geology.



This color-coded map shows the strength of surface gravity around Orientale basin on the Moon, derived from GRAIL data. (The colour scale represents units of "gals" -- 1 gal is about 1/1000 of Earth's surface gravitational acceleration.)

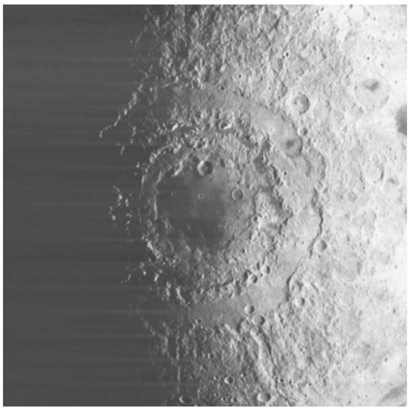
Located along the moon's southwestern limb -- the left-hand edge as seen from Earth -- Orientale is the largest and best-preserved example of what's known as a "multi-ring basin" **(impact craters larger than about 300 kilometres in diameter are referred to as basins)**. With increasing size, craters tend to have increasingly complex structures, often with multiple concentric, raised rings. **Orientale is about 930 kilometres wide and has three distinct rings, which form a bullseye-like pattern.**

Multi-ring basins are observed on many of the rocky and icy worlds in our solar system, but until now scientists had not been able to agree on how their rings form. **What they needed was more information about the crater's structure beneath the surface, which is precisely the sort of information contained in gravity science data collected during the GRAIL mission.**

The powerful impacts that created basins like Orientale played an important role in the early geologic history of our Moon. They were extremely disruptive, world-altering events that caused substantial fracturing, melting and shaking of the young moon's crust. They also blasted out material that fell back to the surface, coating older features that were already there; scientists use this layering of ejected material to help determine the age of lunar features as they work to unravel the Moon's complex history.

THE IMPORTANCE OF ORIENTALE

Because scientists realized that Orientale could be quite useful in understanding giant impacts, they gave special importance to observing its structure near the end of the GRAIL mission. The orbit of the mission's two probes was lowered so they passed less than 2 kilometres above the crater's mountainous rings.


Orientale in 1967 by Lunar Orbiter 4

Of particular interest to researchers has been the size of the initial crater that formed during the Orientale impact. **With smaller impacts, an initial crater is left behind, and many characteristics of the event can be inferred from the crater's size. But it appears that, in large impacts like the one that formed Orientale, the surface violently rebounds, obliterating all signs of the initial impact.** It is estimated that the impact excavated something like 3.5 million cubic kilometres of material

Orientale has been an enigma since the first gravity observations of the Moon, decades ago, and it is only now with the GRAIL details, that a sensible understanding of the formation of the basin, close to 4 billion years ago, has developed. It also sheds light on another mystery: giant impacts like Orientale should have dredged up material from the Moon's deep interior, but instead, the composition of the crater's surface is the same as that of the lunar crust all around it. Modern simulations now show that the deep, initial crater quickly collapses, causing the material around the outside to flow inward, and covering up again the exposed rock.

This new insight suggests that other ringed basins could be discovered by their gravity signatures, such as the large Sea of Tranquility and the Sea of Serenity. It brings us one step closer to understanding the historically familial relationship between Earth, Mars and the Moon, and that our early solar system was a very violent place.

AK, with EarthSky and Wikipedia Notes