A 'radiant' beauty – sulphurous sediments in Becquerel Crater

05 September 2013

The images presented in this mosaic and acquired with the High Resolution Stereo Camera operated by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) on board ESA's Mars Express spacecraft show Becquerel Crater. Inside it, a mountain almost 1000 metres high consisting of layers of sulphurous deposits, is evidence of the eventful climatic history of the Red Planet. The crater is 167 kilometres in diameter, almost 4000 metres deep and is located in the Arabia Terra region, which marks the transition from the Martian highlands to the northern lowland.

In recent years, ESA's Mars Express spacecraft has flown over this region on numerous occasions. Four of the HRSC camera images acquired during these flybys have been combined into an image mosaic, enabling details down to 17 metres in size to be seen (Image 2).

The crater was named after French physicist Antoine Henry Becquerel (1852-1908), who, together with Marie and Pierre Curie, was awarded the Nobel Prize in 1903 for the discovery of radioactivity, and after whom the physical unit for radioactivity is named.

Unusual sedimentary structures – bright, layered deposits – cover the surface of Becquerel Crater. Similar deposits are present in Gale Crater, where NASA's Curiosity rover landed on 6 August 2012. Research has shown that the bright deposits in this region consist of sulphurous rock that is hydrated in places. Sulphates are sulphuric acid salts such as gypsum and, on Earth, are formed when water evaporates. In Becquerel Crater, these sedimentary stacks have formed a mountain almost 1000 metres high, with gently inclined slopes and a flat summit.

Tracking down the processes that generate sulphate deposits

The relative frequency with which the sulphates are present in the Arabia Terra region indicate that a large-scale process is responsible for their creation. It is thought that these sediments have been formed by an interaction of emerging ground water in low-lying regions (impact craters, for example) and dust transported by the wind, possibly in conjunction with ash deposits. The sequence of layers can thus be traced back to seasonal climate fluctuations or changes in the Martian climate over greater periods, caused by the periodic variation of the planet's rotational axis. This and other theories have been intensely debated by experts, as there is still no substantive argument or information from the ground to offer a conclusive answer. The Curiosity rover, in its investigation of Gale Crater, might provide important knowledge in this regard.

The wind has eroded the sediments over the course of time

The layering within the bright sedimentary mountain is clearly visible in images 1, 3 and 4. It is thought that the entire floor of the crater was once covered with these deposits. Sulphurous rocks are relatively susceptible to weathering; consequently, over the course of perhaps more than three billion years, a large part of the layered sediments has been stripped away by the force of the wind, leaving behind an abraded and rounded mountain.

The dark areas in the images are areas covered with a layer of basaltic sands, which probably originated from volcanic ashes and form imposing dune fields in various places on Mars.

Image processing and the HRSC experiment on the Mars Express mission

The colour image (Image 2) was captured using the nadir channel, which is directed vertically down onto the surface of Mars, and the colour channels of the HRSC; the perspective oblique views (Images 1 and 3) were computed from the HRSC stereo channels. The anaglyph image (Image 4), which creates a three-dimensional impression of the landscape when viewed with red/blue or red/green glasses, was derived from the nadir channel and one stereo channel. The view encoded in rainbow colours (Image 5) is based on a digital terrain model of the region, from which the topography of the landscape can be derived.

The High Resolution Stereo Camera was developed at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) and built in collaboration with partners in industry (EADS Astrium, Lewicki Microelectronic GmbH and Jena-Optronik GmbH). The science team, which is headed by principal investigator (PI) Prof. Ralf Jaumann, consists of over 40 co-investigators from 33 institutions and ten countries. The camera is operated by the DLR Institute of Planetary Research in Berlin-Adlershof. The images shown here were generated by the Institute of Geological Sciences at FU Berlin in conjunction with the DLR Institute of Planetary Research in Berlin.

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A mountain of sulphurous sediments in Becquerel Crater

A mountain around 1000 metres high and consisting of bright sedimentary layers has formed inside Becquerel Crater. The deposits partly consist of sulphates that contain water in their crystal structure. Sulphates, such as the calcium sulphate gypsum, are created on Earth by the evaporation of water. It is presumed that these sediments were formed by the interaction of emerging ground water in low-lying regions (impact craters, for example) and dust transported by the wind, possibly in conjunction with ash deposits. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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Vertical plan view of Becquerel Crater

Becquerel Crater, to the right in the centre of the image, is 167 kilometres in diameter. To the southwest of Becquerel (north is to the right in the image) is a second crater, with a heavily eroded rim. Striking features formed by the erosion and deposition of material by the wind, such as an accumulation of bright layers of sulphurous sediments are visible in Becquerel Crater. The dark areas consist of basaltic sands. These sands appear blue-black in colour due to an increase in the contrast of the camera's colour channels; in reality, they are grey-black. It is probable that they originate from volcanic ashes. They form striking dune fields in many places on Mars. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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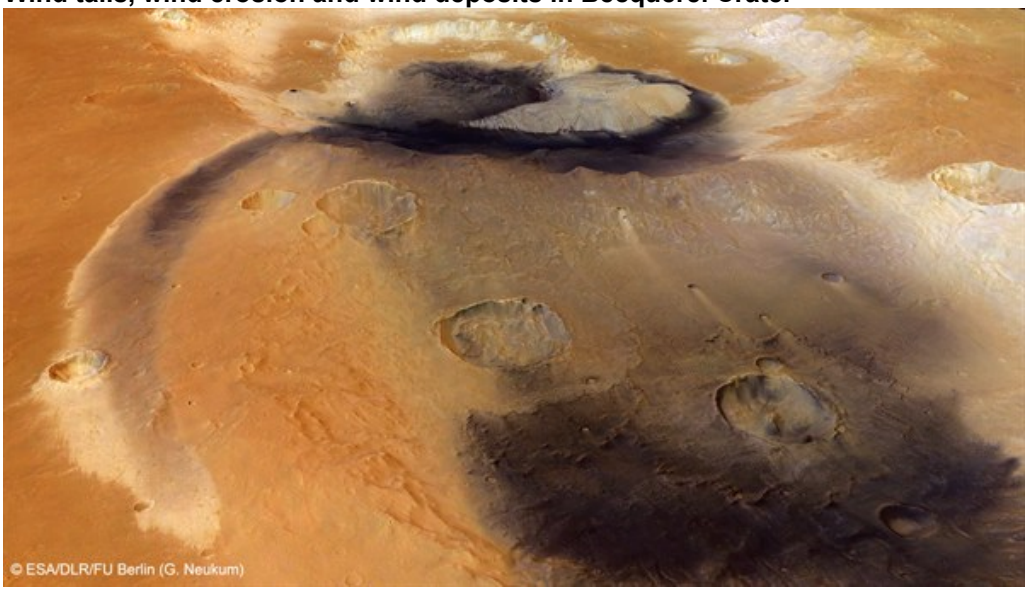
Wind tails, wind erosion and wind deposits in Becquerel Crater



In this perspective view from the southwest of a heavily eroded crater and the rim of Becquerel Crater (in the centre of the image), it is clear how dark sand and dust transported by the wind have been deposited in natural obstacles such as on the crater rim and in wind-protected depressions. These sands appear blue-black in colour due to an increase in the contrast of the camera's colour channels; in reality they are grey-black. They are probably volcanic in origin. In the background and inside Becquerel Crater, a mountain around a kilometre high, consisting of bright, sulphurous sediments can be seen. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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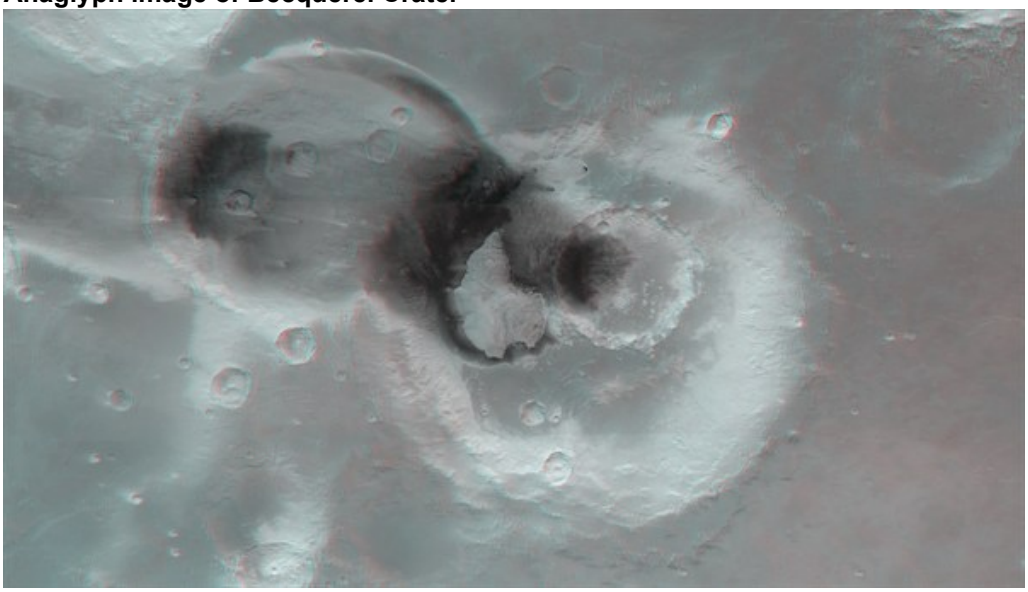
Anaglyph image of Becquerel Crater



Anaglyph images can be generated using data acquired by the nadir channel in combination with data from one of the four stereo channels of the High Resolution Stereo Camera (HRSC) on ESA's Mars Express spacecraft that are directed obliquely towards the planet’s surface. When viewed through red-blue or red-cyan glasses, these provide a three-dimensional impression of the landscape. North is to the right in the image. The difference in altitude between the lowest point in the crater and the surrounding highland is more than 3000 metres. The spatial impression is amplified by increasing the viewing distance. The area of the region shown here is 500 kilometres by 225 kilometres, corresponding to the size of Bavaria and Baden-Württemberg. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December

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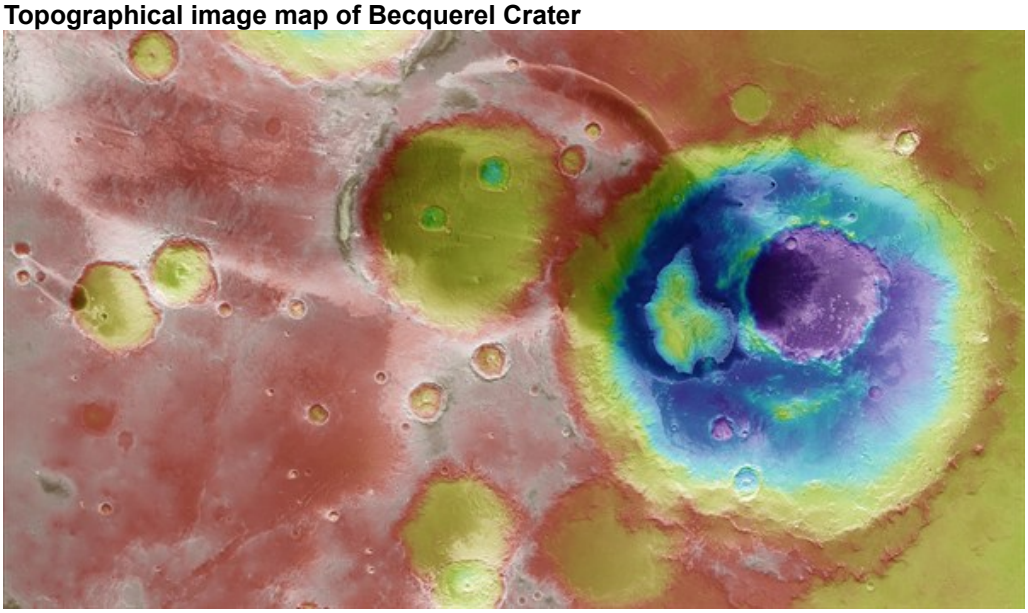
Topographical image map of Becquerel Crater



HRSC stereo image data can be used to calculate topographical terrain models, from which the altitude above or below the reference plane (areoid) of every point shown can be derived. In the absence of 'sea level', the elevation data is referenced to an areoid – a modelled equipotential surface on which everything experiences the same gravitational attraction towards the centre of the planet. Hence, the Arabia Terra region (red and green areas) lies 4000 to 5500 metres below the areoid, and the deepest parts of Becquerel Crater (dark blue) are as much as 7000 metres below the areoid. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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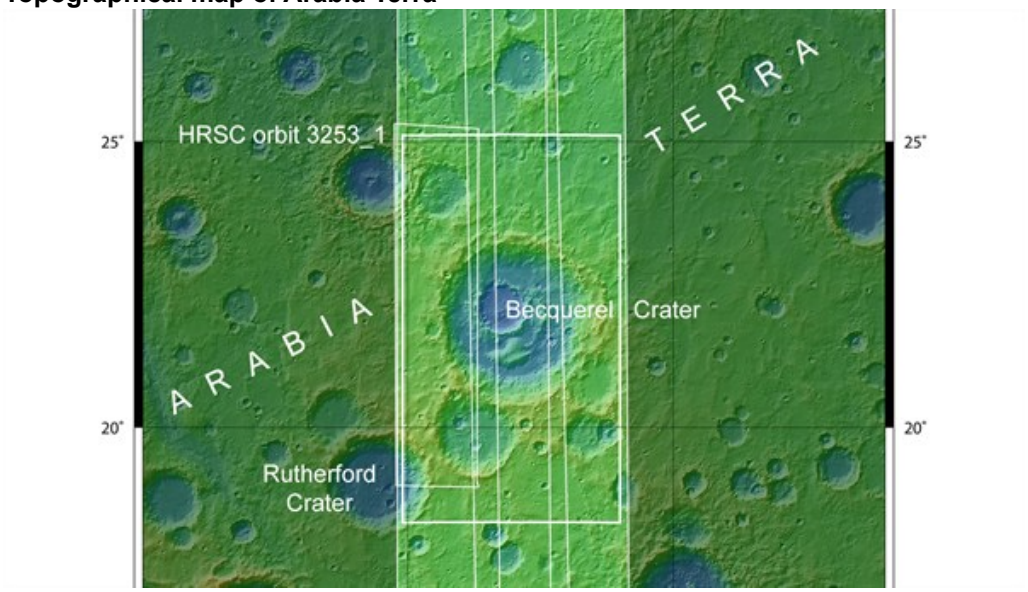
Topographical map of Arabia Terra



Becquerel Crater is located in the north-east of the Arabia Terra region, an extensive highland plateau that forms the transition between the Martian highlands to the south and the lowlands of the northern hemisphere. The High Resolution Stereo Camera operated by DLR on board ESA's Mars Express spacecraft has acquired images of this region numerous times in recent

years. An image mosaic was generated from sections of four image strips (the rectangle marked on the topographical map).

Credit: NASA/JPL/MOLA; FU Berlin.

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