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France-United States space cooperation Curiosity celebrates two Mars years of roving

The **Curiosity** rover is today celebrating its second Mars year on the surface of the Red Planet, almost four Earth years since touching down on 6 August 2012. It remains in good health and all of its instruments are working well. After driving 13 kilometres through Gale Crater, the rover is now scaling the layered sedimentary terrain on the lower slopes of Mount Sharp, which peaks at 5 kilometres above the base of the crater.

ChemCam (Chemistry Camera) and **SAM (Sample Analysis at Mars)** are two French-U.S. instruments on Curiosity. Both instruments were built with CNES oversight by research laboratories attached to CNRS, the French national scientific research centre, and French universities. The IRAP astrophysics and planetology research institute was the lead laboratory for ChemCam and the LATMOS atmospheres, environments and space observations laboratory and the LISA inter-university laboratory for the study of atmospheric systems were the leads for SAM. Scientists and engineers have now been operating the two instruments on the surface of the Red Planet for two Mars years from the French Instruments Mars Operations Centre (FIMOC) at the Toulouse Space Centre.

ChemCam has fired its power laser more than 337,000 times, revealing an unexpectedly diverse array of magmatic and sedimentary rocks. Its measurements have shown that some of these rocks are comparable to the Archeozoic formations composing Earth's primitive crust, completely changing our view of Mars' surface. ChemCam has also detected minerals that formed at a later stage through precipitation of phosphates, sulphates, calcium and manganese. It is also studying the planet's current environment with regular measurements of abundance variations in the water and carbon dioxide columns in the atmosphere.

The **SAM** instrument suite is a fully fledged laboratory designed to conduct in-situ analysis of Mars' surface and subsurface, and to collect and analyse samples of its atmosphere. The broad palette of analyses that SAM is able to carry out has yielded a wide variety of innovative results in two Mars years scouting the planet. In particular, it has enabled scientists to revise abundance models of compounds in the atmosphere, observed sporadic plumes of methane whose origin is still uncertain, dated Gale Crater and exposed rocks analysed by Curiosity, detected the presence and then disappearance of water in the Hesperian period on Mars and found perchlorates—a highly reactive chemical species—everywhere on its surface, as well as organic compounds.

Curiosity's discoveries. The rover team has closely studied nine sites over the last two Mars years. Yellowknife Bay is a paleo-lake with stratified layers of sandstone several metres thick that have revealed that Mars was once habitable in its ancient past, the mission's main goal. The Darwin, Cooperstown and Kimberley sites have enabled the mission's science team to identify various fluvial and lacustrine episodes that would have required a climate very different to what we see today, with water present in large quantities. In the Pahrump Hills, Curiosity has studied the base of Mount Sharp and a succession of contact zones, between a lacustrine and an aeolian deposit (Marias Pass and Bridger Basin). The large sand dune now lying between the rover and the layered terrain of Mount Sharp is still active and has been sampled at the site called Gobabeb. Curiosity is currently on the Naukluft Plateau, where it is studying signs of strong erosion. The diverse composition of magmatic and sedimentary rocks is a major result for the mission, as it represents the terrain surrounding the landing site and the surface crust. New geologic units will be investigated in the years ahead to tie Curiosity's observations to satellite observations and models of Mars' broader geological history.

Key mission dates

ChemCam and SAM instruments selected:

December 2004

Launch:

26 November 2011

Landing:

6 August 2012

First Mars year on surface:

29 June 2014

Second Mars year on surface:

11 May 2016

IRAP: Institut de Recherche en Astrophysique et Planétologie (CNRS/Université Toulouse III – Paul Sabatier)

LATMOS: Laboratoire atmosphères, milieux, observations spatiales (CNRS/Université Versailles Saint-Quentin-en-Yvelines/Université Pierre et Marie Curie, IPSL)

LISA: Laboratoire Interuniversitaire des Systèmes Atmosphériques (CNRS/Université Paris-Est Créteil/Université Paris Diderot)

LISA and LATMOS are part of the Institut Pierre Simon Laplace, a federation of laboratories focusing on research into the Earth system and other objects in the solar system.

CEA: Commissariat à l’Energie Atomique et aux Energies Alternatives (Saclay), the French atomic energy and alternative energies commission

Géoressources: Géologie et Gestion des Ressources Minérales et Energétiques (CNRS/Université de Lorraine, Nancy)

IAS: Institut d’Astrophysique Spatiale (CNRS/Université Paris Sud, Orsay)

ISTerre: Institut des Sciences de la Terre (CNRS/Universités de Savoie/Université Joseph Fourier, Institut de Recherche pour le Développement, Institut Français des Sciences et Technologies des Transports, de l’Aménagement et des Réseaux, Grenoble)

LGL-TPE: Laboratoire de Géologie de Lyon, Terre, Planètes, Environnement (CNRS/Université Claude Bernard, ENS Lyon)

LPGN: Laboratoire de Planétologie et de Géodynamique de Nantes (CNRS/Université de Nantes, Nantes)

IMPMC: Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie (CNRS /Sorbonne Universités, Université Pierre et Marie Curie, Institut de Recherche pour le Développement, Museum National d’Histoire Naturelle)

LAB: Laboratoire d’Astrophysique de Bordeaux (CNRS / Université de Bordeaux 1 / Observatoire Aquitain des Sciences de l’Univers)

OMP: Observatoire Midi-Pyrénées (CNRS/Université Toulouse III – Paul Sabatier, CNES, Institut de Recherche pour le Développement)

More information at <https://msl-curiosity.cnes.fr>

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