

## Rivers of Mars by Professor Sanjeev Gupta on 22-4-2022

Professor Gupta is a geologist working at Imperial College, studying the geology of the Earth, and has no specialised knowledge of other parts of the solar system. However, he is now a valued member of the NASA teams studying Mars, first with the Curiosity Rover, and later the Perseverance Rover.

There are no 'canals' on Mars – as telescopes improved surface detail began to be observed, particularly by the Italian astronomer GV Schiaparelli in the late 19C, and he first suggested there were 'canali'. The term took hold, and in 1911 the New York Times carried an article saying that Martians had built two large canals in two years! The English astronomer, Walter Maunder, was sceptical; he showed a circular board covered in dots to a class of students – those at the front saw dots – but those further back saw lines – an optical illusion. The belief in the 'canals' persisted into the 1920s. (Both Maunder and his wife worked at the Royal Observatory, Greenwich; and were famous for making important discoveries. Coincidentally their house is within sight of where Professor Gupta now lives in Brockley.)

In 1971 a picture taken by the Mariner 9 probe showed a 'river'. In 1976 the Viking mission pictured a dendritic pattern, best explained by as having been formed by precipitation.

When first formed, about 4 billion years ago, Mars is thought to have had a hot core and liquid water on its surface. It is about a tenth the mass of the earth, has no tectonic plate system, and a very thin atmosphere. By about 3.5 billion years ago the last of the liquid water had evaporated off – the hot core had cooled, removing any related magnetic field (which would have provided a shield against the solar wind). Since then the Martian surface has only been altered by collisions by comets etc, and vulcanism. (The oldest rocks on Earth have all been affected by tectonic action.) This is still speculative, but by comparing the river systems on Earth with the surface features on Mars Professor Gupta thinks this is a probable scenario.

However, he mentioned an unsolved problem with this scenario called the 'faint young Sun' paradox. The young sun probably had an output of only 70% of its current output which would mean that water on Mars would be frozen, yet the geology shows all the signs of liquid water having been present at that time. A similar problem applies to Earth.

Mars has young, relatively featureless, terrain in the north. In the mid-latitudes the original rocky terrain survives. Hear a 50km long 'river system' shows a typical meander. 'Lakes' appear in craters, with characteristic waterfall erosion patterns where rivers dropped into them, and formed deltas. One such lake shows how it was already drying up while the river still flowed. There are rounded pebbles, and even rounded boulders brought in by mud slides.

The Perseverance rover is development of the Curiosity Rover, and shares design features. They both have six broadly spaced wheels, and are fitted with a nuclear power source as the equipment they carry has to be kept warm (even the arm joints). The temperature on Mars ranges from -140 to +35°C with a mean of -63°C.

Landing the rovers was quite spectacular. The spacecraft carrying the rover released a parachute for initial retardation in the thin atmosphere at an altitude of 13km. The heat shield was jettisoned as the spacecraft slowed, and cameras on the rover were then used to control the descent to locate the landing spot. As it neared the surface thrusters were ignited to further slow the spacecraft, to a point where it hovered about 20 metres up and winched the rover down to the ground. (The parachute was made by a company that specialises in space parachute manufacture - in Tiverton in Devon.)



**Curiosity** Rover mission, from August 2012 to present (though designed for a 2 year life).

One aim was to assess the Habitability of Mars. Requirements are liquid water, key chemicals, and a source of energy. The target area was the Gale Crater, the largest on Mars with a mountain in the middle – the mountain caused by an enormous impact, and loose ejecta falling back to fill the crater - but later lost.

Mars has (in round figures) a 24½ day length and the team controlling the rover began by working in Mars time – making Professor Gupta feel permanently jet-lagged while doing so. The round-trip message time to the rover is 14 min.

One feature was a dune field. Dunes had been studied by Ralph Bagnold at Imperial College, where he purpose-built a wind tunnel. He was there both before and after WW2 (during the war he was famous as the leader of the Long Range Desert Group). Dune fields are named after him. They form under water as well as on the surface, giving a characteristic cross stratification – and were found by the Curiosity Rover.

**Perseverance** Rover mission, from February 2021 to present.

Professor Gupta referred to the Perseverance rover as a walking rucksack. It is equipped with 46 titanium capsules into (most of) which core samples from surface rocks can be sealed. These will be retrieved and returned to Earth in 2033 by visiting spacecraft – the most expensive samples ever! The first sample was to be from a soft rock – the rock was drilled, the sample loaded into its capsule – and the capsule checked; it was empty. The core had turned to dust; the sample was declared as being of the atmosphere. The next core came from a hard rock, and neatly filled its capsule.

It even has a miniature helicopter (drone). The helicopter comprises a solar panel to charge its battery; twin lightweight blades; and a (smartphone) camera; it is controlled from the rover, and gives a considerably extended field of view – most useful for spotting features of interest.

Perseverance is carrying out Geologic exploration in the Jezero Crater; investigating Habitability and Biosignatures; and preparing for manned exploration. It is equipped with several cameras, a control unit and antennas, a drill and manipulator arms to take the core samples, and on the rover's mast two instruments provide high-resolution imaging and three types of spectroscopy for characterizing rocks and soil from a distance, also helping to determine which rock targets to explore.

The rover has managed to capture footage of a Mars solar eclipse when Phobos - one of Mars' two moons - passed in front of the Sun. Phobos is a potato shaped asteroid captured by Mars, and not large enough to produce a total eclipse.

Professor Gupta said he could do as much geology on Earth in half an hour as the rovers did in a week on Mars. He said there was a proposal to send a geologist to orbit Mars in a spacecraft to speed up the process; but that the conditions – low temperature, and cosmic ray bombardment - would make a manned landing too hazardous – something which he doubted would happen.