ENCOUNTER WITH COMET 19P/BORRELLY: RESULTS FROM THE DEEP SPACE 1 MINIATURE INTEGRATED CAMERA AND SPECTROMETER. L. A. Soderblom[1], T. L. Becker[1], G. Bennett[1], D. C. Boice[2], D. T. Britt[3], R. H. Brown[4], B. J. Buratti[5], C. Isbell[1], B. Giese[6], T. Hare[1], M. D. Hicks[5], E. Howington-Kraus[1], R. L. Kirk[1], M. Lee[5], R. M. Nelson[5], J. Oberst[6], T. Owen[7], B. R. Sandel[4], S. A. Stern[2], N. Thomas[8], and R. V. Yelle[4,9], [1]United States Geological Survey, 2255 North Gemini Drive, Flagstaff AZ 86001 (lsoderblom@usgs.gov), [2]Southwest Research Institute, [3]University of Tennessee, [4]University of Arizona, [5]Jet Propulsion Laboratory of the California Institute of Technology, [6] DLR Institute of Space Sensor Technology and Planetary Exploration, [7]University of Hawaii, [8]Max Planck Institute für Aeronomie, [9]Northern Arizona University.

Introduction: On September 22, 2001 the ion propulsion-powered NASA-JPL Deep Space 1 spacecraft passed within 3700 km of 19P/Borrelly, a Jupiter-family short-period comet. Of four taxonomic cometary classes identified, the Halley group (60%) and Borrelly group (30%) constitute most of the observed comets [1]. Earth-based observations of gas composition show the Borrelly group to be depleted in C-chain molecules relative to the Halley group; both show similar high levels of water and ammonia. Deep Space 1 (DS1) is the first spacecraft to visit a member of the Borrelly group. During the last ~90 minutes prior to close approach, ~25 visible-wavelength images and 45 short-wavelength infrared spectra (1.3-2.6 μm) were collected by the Miniature Integrated Camera and Spectrometer (MICAS) instrument aboard DS1. The images cover solar phase angles of ~90°-to-50° providing stereoscopic coverage of the coma, jets, and nucleus. The highest resolution image is ~48 m/pixel. At encounter, the DS1 spacecraft was close to the plane of the ecliptic and ahead of the earth ~50° in terms of orbital longitude. During approach the view of the comet from DS1 was in the direction of ecliptic south as it rose in its inclined orbit toward the S/C. The encounter occurred very near a few weeks after perihelion.

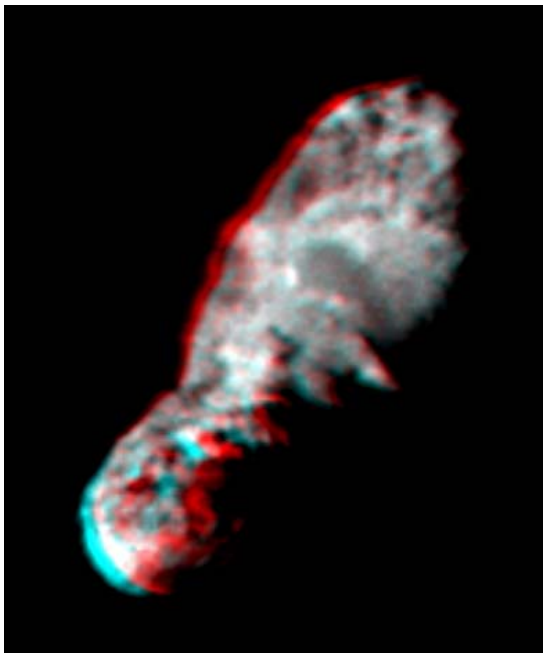

Figure 1. Anaglyphic composite of Borrelly's nucleus from two high resolution views: 49 and 65 m/pixels.

Earlier Observations:
19P/Borrelly is a Jupiter-family short period comet discovered on December 28, 1904 by Alphonse Louis Nicolas Borrelly of Marseilles, France. The comet has an orbital period of ~7 years, a perihelion ~1.36 A.U., and an inclination of ~30°. During 1936 and 1972 close approaches to Jupiter caused substantial perturbations of the orbit making recovery difficult in subsequent apparitions. Historically, Borrelly's coma has persistently exhibited a strong sunward asymmetry with a sunward jet or anti-tail projecting from the nucleus. A'Hearn and colleagues estimated the dust production parametric Afρ at ~650 cm and an OH production rate ~2×10^{28} molecules/s [2]. Observations from the Earth with Hubble Space Telescope by Lamy and colleagues gave an estimated rotation period 25±0.5 hours, assuming 0.04 albedo semi-major axis 4.4 ±0.3 km and semi-minor axis 1.8 ±0.15 km, and about 8% active surface area [3].

DS1 MICAS Observations: The close-up observations reveal an elongate nucleus exhibiting complex topographic, geologic, and photometric variations (fig. 1). The nucleus is about 8 km in length remarkably consistent with the Lamy model [3]. At the time of encounter (soon after perihelion) the near-nucleus coma was dominated by a prominent jet that emanated roughly normal to long axis of nucleus from a broad central cavity into a direction ~30° from the sun line and ~10° above the ecliptic. The near-nucleus coma exhibits two types of dust jets: fan-like (like those observed at Comet Halley) and highly collimated jets (fig.2). The collimated jets have cylindrical cores ~0.5 km in diameter and ~5km in length and hemispheric-shaped bright bases; in two cases they are traceable to "dark smudges" in or adjacent to this cavity. The collimated jets are thought to consist of coarser particles (10-100 μm) that travel in a collimated beams undeflected by the radially expanding gas envelopes. The nucleus exhibits two terrain types: 1) the central cavity and sunward-most end show smooth, rolling plains

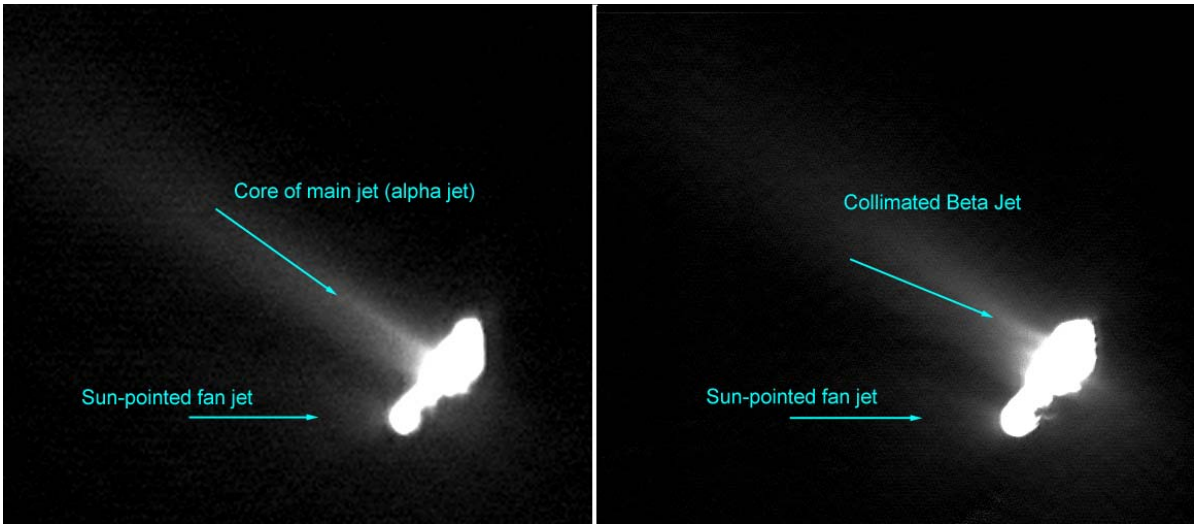

Figure 2. Borrelly's jets are resolved in the DS1 MICAS images into fan-shaped jets and two sets of highly collimated jets.

with mesa-like features and 2) the regions near the ends of the elongated body show mottled, variegated, rubble-textured terrains with much darker spots. The entire nucleus is extremely dark with geometric albedos in the range of 0.01 to 0.03; the average Bond albedo is ~0.006. Short-wavelength infrared spectra show 1) a strong red-ward slope from 1.3-to-2.6 μm, a very hot (345K to 300K) and dry (no trace of H_2O ice) surface consistent with Earth-based observations that <10% of the surface is actively sublimating. The spectra show an absorption feature at 2.39 μm that is consistent with those seen in some C-H compounds that have been suggested for comet nuclei.

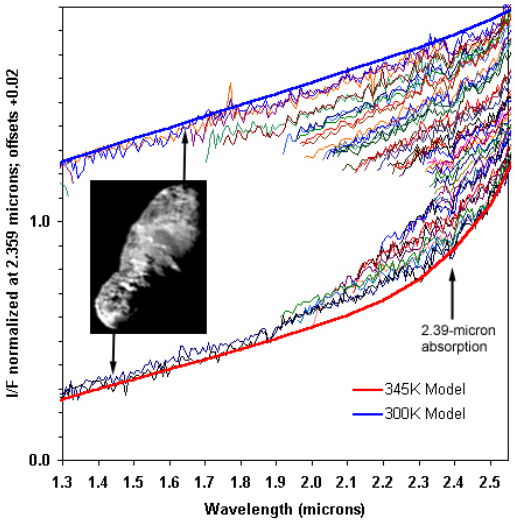

Figure 3. Forty-five short-wavelength infrared spectra collected of the Borrelly nucleus. Central spectra were partially saturated. Sunward-most end shows highest temperature. Absorption near 2.39μm prevalent in all spectra. No trace of H2O ice is evident in the Borrelly's strongly red-sloped spectrum.

Conclusion: We deduce that the nucleus' rotation axis is roughly aligned with prominent main jet (RA 223°, DEC -15°). This would place the sub-solar latitude at ~60° N and would place the rotation pole and coplanar areas of the nucleus in constant sunlight during perihelion passage. Such a direction for the rotation pole would be consistent with the stable rotation of the nucleus around its short axis. The non-gravitational forces arising from the main jet would minimally disrupt this stable configuration.

References: [1] M. D. Hicks PhD Thesis; [2] M. F. A'Hearn, R. L. Millis, D. G. Schleicher, D. J. Osip, P. V. Birch (1995) Icarus v. 118, no. 2, 223-270; [3] P.L. Lamy, I. Toth, H. A. Weaver (1998) Astron. And Astrophys. 337, 945-954.