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The Aftermath of the 2009 Impact on Jupiter from Thermal-IR Spectroscopy

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The unexpected collision of an asteroidal or cometary body with Jupiter on July 19^{th} 2009 was only the second observed impact event in the history of ground-based observations of the giant planets. In the days that followed, the impact ejecta field was characterised by multi-spectral observations from the mid-IR to the near-UV using a wide range of ground-based and space-based observatories. Thermal-IR imaging from IRTF /MIRSI on July 20^{th} detected the warm impact scar at all wavelengths except near 7 μm (sensitive to stratospheric methane emission), indicating that the atmospheric perturbation resulting from the impact was restricted to the lower stratosphere and upper troposphere. These results were confirmed by Gemini-N/Michelle, Gemini-S/TReCS and VLT/VISIR thermal observations in the following days, as the impact field elongated and became sheared by Jupiter's zonal jets. Enhanced Q-band (17-25 μm) emission was attributed to elevated temperatures and stratospheric particulates, but enhanced N-band emission (8-13 μm) could only be explained by significant quantities of ammonia (NH_3) gas exhumed from the tropospheric reservoir and emplaced into the warm stratosphere.

Spatially resolved N-band spectra from Gemini-S/TReCS, with multiple observations providing centre-to-limb variability of the enhanced emission, were used to derive 3D maps of the enhanced temperatures and excavated NH_3 distribution. We use these to estimate the size and energy of the impactor and the mass of tropospheric air exhumed by the impact shock and subsequent upwelling. High-resolution VLT/VISIR spectroscopic observations taken at three epochs (July-November 2009) following the impact were used to track (a) the rate of stratospheric NH_3 depletion by photolysis and dynamic redistribution; and (b) the radiative cooling timescale of the lower stratosphere. Imaging observations provide an excellent temporal database to determine the expansion rate of the impact and ejecta fields as they cooled. Finally, residual spectra from N-band retrievals are interpreted as the signatures of material supplied to the Jovian atmosphere by the incoming projectile, allowing us to constrain the possible composition and origin of the impacting body.

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