# IN-SITU MINERALOGICAL ANALYSIS OF THE VENUS SURFACE USING X-RAY DIFFRACTION.

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**Introduction:** The history of a planet is written in its rocks and the minerals they contain. Because minerals are stable under known ranges of temperature, pressure and composition, a rock comprised of specific minerals can be used to identify the conditions under which it formed and subsequent environmental changes, based on individual mineral stability ranges and the presence or absence of equilibrium between them. More than optical, elemental or isotopic analysis, definitive mineralogical analysis with X-ray Diffraction (XRD) provides information about habitability: T, P conditions of formation, present/past climate, water activity, the activity of biologically significant elements and the like. Such determinations are not possible if qualitative mineralogical data are obtained or if the complete mineral assemblage is not characterized.

**The CheMinV Instrument Intended for Landed Venus Science:** Like MSL-CheMin [1], CheMinV [2] is a powder X-ray Diffractometer. For more than a century XRD has been the preferred method for mineralogical analysis of unknowns in terrestrial laboratories. CheMinV will utilize a Silicon Drift Detector (SDD) integral to the instrument to determine the chemical composition of the exact sample used for diffraction analysis. It is important to note that the major element chemistry of every mineral present in the sample at >5 wt. % concentration is determined using XRD data alone. XRF is only required to quantify minor or trace elements which are not reflected in the lattice parameter measurements.

CheMinV is the product of a decade of post-CheMin technology development, yielding a >10X increase in data acquisition speed, a 50% reduction in instrument mass and volume and improved pattern resolution. X-ray Diffraction analyses of drilled and powdered samples on Venus by CheMinV will yield:

- Identification of all minerals present >1 wt. %.
- Quantification of all minerals present >3 wt. %, including their structure states and cation occupancies.
- Abundance of all major elements present in each mineral (H and above) from their refined lattice parameters, for minerals present at >5 wt.%.
- Valence state of all major elements, including speciation of multi-valent species such as Fe for minerals present at >3 wt% from their empirical formulas.

*There are no spacecraft instruments currently in NASA's planetary science inventory that can claim even one of these capabilities.*

Fig. 1 shows the proposed geometry of the CheMinV instrument. Further details and examples of its mineralogical capabilities are presented in [2].

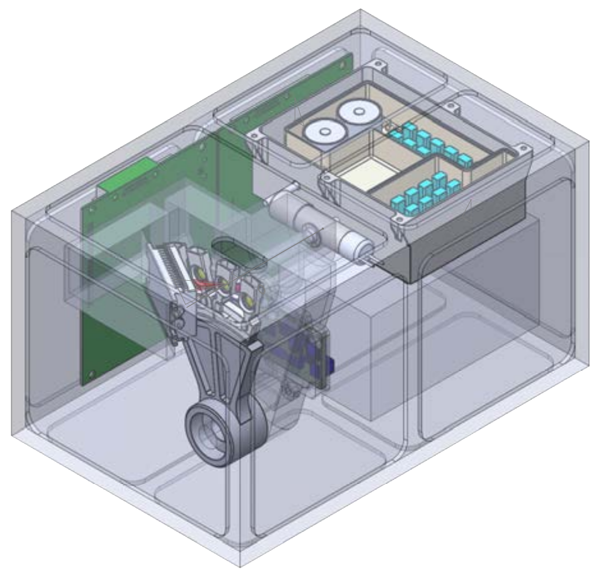

*Fig. 1: 3D model of CheMinV. Dimensions: 290 X 190 X 162 mm. Samples are delivered through a funnel (not shown) positioned over the cell to be analyzed.*

CheMinV meets the requirements of five investigations described in the recent Venus GOI document [3], including **I. A. HO(1)**: Evidence for silicic rocks and/or ancient sedimentary rocks; **I. A. RE(1)**: Evidence of crustal recycling; **III. A. GC(1)**: Determine elemental chemistry, mineralogy and rock types representative of global geologic units; **III. B. LW(1)**: Evaluate mineralogy, oxidation states, etc. of weathered rock exteriors; and **III. B. GW(2)**: Determine the causes and extent of global weathering.

**References:** [1] Blake, D.F., et al. (2012). Space Sci. Rev. **170**:341-399, DOI 10.1007/s11214-012-9905-1. [2]. Decadal Survey Paper, Blake, D.F. et al.; http://surveygizmoresponseuploads.s3.amazonaws.com/fileuploads/623127/5489366/125-93530df9ecea46107c28e3d1693031af_BlakeDavidF.pdf [3]. Venus Goals, Objectives and Investigations https://www.lpi.usra.edu/vexag/reports/VEXAG_Venus_GOI_Current.pdf