deposits, using newly available laboratory sulfate mineral spectra [e.g., *Cloutis et al.*, 2006], have allowed us to provide a new assessment of the abundance of hydrated minerals in the region.

[6] In this study, we have employed a range of data sets in addition to the OMEGA spectral data to analyze the distribution of hydrated minerals, including geologic and morphologic maps of the north polar region [*Tanaka et al.*, 2008; *Tanaka*, 2005; *Rodriguez et al.*, 2007; *Tanaka and Hayward*, 2008] high-resolution spectral data from CRISM, altimetry data from the Mars Global Surveyor/Mars Orbiter Laser Altimeter (MGS/MOLA) [*Zuber et al.*, 1992, *Smith et al.*, 2001], and visible wavelength images from the MRO Context Camera (CTX) [*Malin et al.*, 2007], the MRO High Resolution Imaging Science Experiment (HiRISE) [*McEwen et al.*, 2007], and the Mars Odyssey orbiter's Thermal Emission Imaging System (ODY/THEMIS) [*Christensen et al.*, 2004a].

[7] In section 2, we provide an overview of the geologic units and features of the north polar region, with an emphasis on Olympia Planum. In section 3, we describe the compositional properties of Olympia Planum, provide a background on terrestrial gypsum deposition, and describe previous hypotheses for deposition of the Olympia Planum gypsum. Section 4 details the methods we used to verify the OMEGA sulfate detection and to produce a new map of the distribution of hydrated minerals, and section 5 presents our spectral maps as well as correlations between our maps and other data sets. Section 6 describes our efforts to model the abundances of gypsum in both CRISM and OMEGA observations using laboratory data, and section 7 presents our interpretations of our findings in the context of the regional geologic history.

2. Regional Geologic Units

[8] The north polar region of Mars exhibits a complex and dynamic geologic history that extends through the Amazonian. In this section, we provide an overview of previous work on the regional geologic units, with an emphasis on the history and current state of the north polar erg.

2.1. Pre-MGS Geologic Interpretations

[9] The smoother surfaces and lower crater densities as compared to the southern highlands observed in the northern basin since Mariner 9 has suggested that the northern basin was resurfaced at some point in Martian history [e.g., *Scott and Carr*, 1978], but what processes did the resurfacing and when it happened has only become apparent in more recent mapping efforts. The availability of higher-resolution images and other data sets has steadily decreased the apparent age of the north polar basin materials from the Noachian-Hesperian ages interpreted from Mariner 9 data [*Scott and Carr*, 1978], to the Hesperian-Amazonian ages interpreted from Viking data, [*Dial*, 1984; *Scott and Tanaka*, 1987], and more recently, to the exclusively Amazonian ages interpreted from MGS and ODY data [*Tanaka et al.*, 2003, 2008; *Tanaka*, 2005]. The inferred source and nature of the materials has also changed dramatically. During the Viking era, the materials filling the northern basin, or the Vastitas Borealis Formation (VBF), were interpreted as Hesperian volcanic flows with varying degrees of degradation [e.g., *Scott and Tanaka*, 1987]. With higher-resolution images from MGS and ODY, the VBF is currently interpreted as late Hesperian outflow sediments that have been extensively reworked by periglacial processes since the early Amazonian [e.g., *Tanaka*, 2005].

2.2. Recent Geologic Interpretations

[10] According to recent geologic mapping [*Tanaka*, 2005; *Tanaka et al.*, 2008], the geology of the north polar region can be described by distinct units separated in time and space, as shown in Figure 2. In the plains, the Vastitas Borealis interior and Scandia region units have been mapped as having been emplaced during the early Amazonian by sediments from catastrophic outflows originating at lower latitudes, and reworking of those sediments by phreatic processes such as mud volcanism. The Rupes Tenuis unit is superposed unconformably on top of the plains units, and is interpreted to have most likely formed by redeposition of sediment from the previously much more extensive Scandia unit. The Rupes Tenuis unit makes up the terrace-forming, stratigraphically lowest section of the layers previously classified as the polar basal unit [*Edgett et al.*, 2003; *Fishbaugh and Head*, 2005], and has a maximum observed thickness of ~1300 m [*Tanaka et al.*, 2008]. An extended period of erosion during the Middle Amazonian may have considerably reduced the size of the Rupes Tenuis unit, which, in the plains, may have left behind impact-cemented plateaus such as those exposed at the mouth of Chasma Boreale and in the nearby Escorial pedestal crater plateau [*Tanaka et al.*, 2008].

[11] *Tanaka et al.* [2008] have classified the upper section of the basal unit as the Planum Boreum cavi unit, which formed from many episodes of sand deposition, and has been described as a paleoerg deposit [*Byrne and Murray*, 2002; *Fishbaugh and Head*, 2000, 2001, 2005; *Tanaka*, 2005]. Major geologic evidence for the paleoerg includes the cross-bedded nature of the Planum Boreum cavi unit and the unit's tendency to be thickest in depressions in the Rupes Tenuis unit [*Tanaka et al.*, 2008]. Additionally, the Planum Boreum cavi unit appears to make up the bulk of the topography of Olympia Planum, which suggests that Olympia Planum may have a long history of aeolian activity.

[12] The Planum Boreum 1 unit, which makes up the bulk of the lower polar layered deposits, unconformably overlies the Planum Boreum cavi unit, and exhibits up to ~1500 m of even, fine layering, most likely composed of air fall deposits [*Blasius et al.*, 1982; *Fishbaugh and Head*, 2005; *Malin and Edgett*, 2001; *Milkovich and Head*, 2005, 2006; *Tanaka*, 2005; *Tanaka et al.*, 2008]. The emplacement of the Planum Boreum 1 unit was followed by another extensive period of erosion, during which katabatic winds may have first carved the spiral troughs that are now being exposed throughout Planum Boreum, potentially by similar processes [*Tanaka et al.*, 2008].

[13] Following the period of erosion, the troughs were subsequently filled in by ~100 m of dark sediments that now comprise the Planum Boreum 2 unit [*Rodriguez et al.*, 2007; *Tanaka et al.*, 2008]. The Planum Boreum 2 unit makes up the lowest portion of the upper layered deposits or "banded terrain" [*Howard et al.*, 1982; *Tanaka*, 2005], and appears to be composed of ice-free sand and dust, which is mobilized to form the extensive low-albedo surfaces that mantle much of the periphery of Planum Boreum (Figure 1) [*Rodriguez et al.*, 2007]. The low-albedo surfaces are thick enough to obscure or partially obscure the spectral signature of the water ice below, but not to obscure the underlying morphology, leading