THE SEARCH FOR METHANE GAS EMISSION FEATURES ON MARS. G. Komatsu[1, 2], G. G. Ori[1], M. Cardinale[1], J. M. Dohm[3], V. R. Baker[3], D. A. Vaz[4, 1], R. Ishimaru[2], N. Namiki[2] and T. Matsui[2], [1]International Research School of Planetary Sciences, Università d'Annunzio, Viale Pindaro 42, 65127 Pescara, Italy (goro@irsps.unich.it), [2]Planetary Exploration Research Center, Chiba Institute of Technology, 2-17-1 Tsudanuma, Narashino-shi, Chiba 275-0016, Japan, [3]Department of Hydrology and Water Resources, University of Arizona, Tucson 85721, AZ, USA, [4]Centre for Geophysics, University of Coimbra, Av. Dr. Dias da Silva, 3000-134 Coimbra, Portugal.

Introduction: Because methane can only persist for a few hundred years in the Martian atmosphere, its recent detections [1–5] indicate a present-day mechanism for its replenishment. It is of major importance to know the mechanism for replenishment and the nature and extent of the source (e.g., local vs. regional, and single vs. multiple). Investigations show that the gas is enriched over specific regions of the planet with temporal variations [e.g., 2–5], although whether or not these regions are the real sources of methane is still a matter of unsolved debate. The detected methane gas may result from (1) direct release from its place(s) of origin, and/or (2) indirect release by the decomposition of methane clathrate [6–10].

On Earth, methane gas is often emitted from areas marked by gas- and gas hydrate-related landforms. Therefore, identifying such features is expected to provide clues on understanding the methane-replenishing mechanisms on Mars. Although there have been works on potential gas- and gas hydrate-related (for both CH_4 and CO_2) features on Mars in the past [e.g., 11–18], relatively little attention has been paid to their roles to this date.

We have conducted a preliminary investigation of possible gas- and gas-hydrate-related features on Mars including those in the suggested methane-enriched regions (Nili Fossae, Syrtis Major, and Terra Sabae) [4] using images acquired by various recent Mars missions. Isidis Planitia was also examined because of its close geological relationship with Nili Fossae and Syrtis Major. Global mapping of methane concentration/distribution is far from complete. In addition, full determination of its source(s) may not be possible currelty as in the case of a recent finding that may show a possible present-day methane source at the remnant north polar cap from which the methane gas ransfers through the atmosphere to the regions mentioned above [5].

Besides the present-day emission, methane gas may have been emitted throughout the Martian history. Thus, it is important to study not only the present-day emission but also that of the geological past for all terrain types of Mars. As such, our investigation intends to cover the entire planet following the early works [11–18]. In particular, we focus on specific landforms known to be associated with high methane emission on Earth (mud volcanoes, pockmarks, etc.).

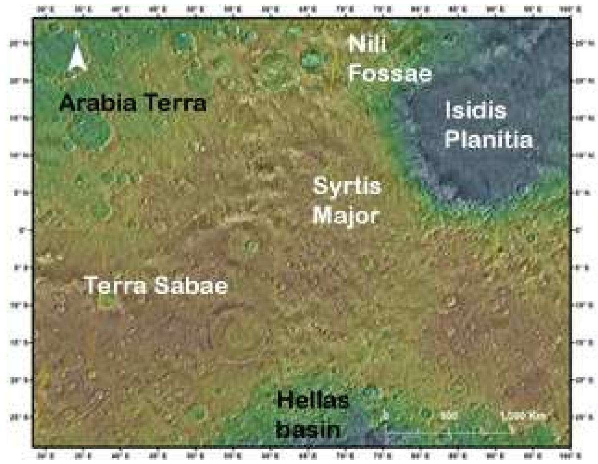

Fig. 1. Locations of the studied areas. THEMIS IR daytime image mosaic over MOLA topography.

Preliminary results:

Nili Fossae. A system of faults and fractures characterizes Nili Fossae, and dark-toned flows from Syrtis Major partly inundate some of these tectonic structures. The structures may form conduits for the transferal and eventual release into the atmosphere of subsurface methane and other volatiles. The recent detection of serpentine [19] in the Nili Fossae region should be considered as a possible contributor to methane production, since serpentinization leads to methane production on Earth [e.g., 20].

Fig. 2. Faults and fractures of Nili Fossase. THEMIS IR daytime image mosaic.

Syrtis Major. Syrtis Major is considered to be a volcanic field comprised of low-shield volcanoes of Hesperian age. A number of dark-toned flows spread radially from two distinct calderas. The dark-toned flows are generally interpreted to be solidified lava [e.g., 21]. Because methane emission is observed from terrestrial volcanoes [e.g., 22], Syrtis Major may analogously be hypothesized to be a site of magma-driven gas venting.

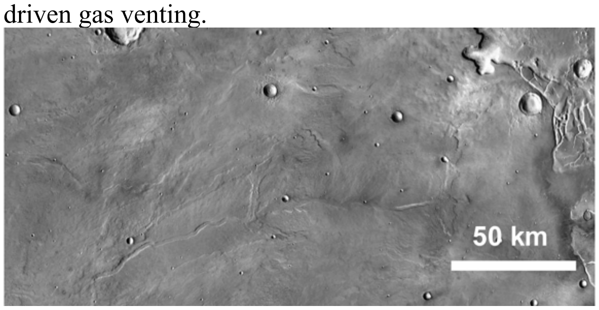

Fig. 3. Probable lava plains of Syrtis Major. THEMIS IR daytime image mosaic.

Isidis Planitia. The Isidis basin floor is characterized by the presence of massive, regionally-occurring, dark-toned deposits of Hesperian-Amazonian age and associated, often aligned mounds. The mounds are <1 km in diameter and often have summit craters. The interpretations for the mounds include pseudocraters [23], peri-glacial features [e.g., 24], volcanic cones [e.g., 25], and mud volcanoes [e.g., 26, 13]. Among these hypotheses, mud volcanoes are of particular interest since such features on Earth are observed to emit methane of elevated concentrations to the atmosphere [27]. However, ice, volcanic gases, and other possible sources should not be overlooked.

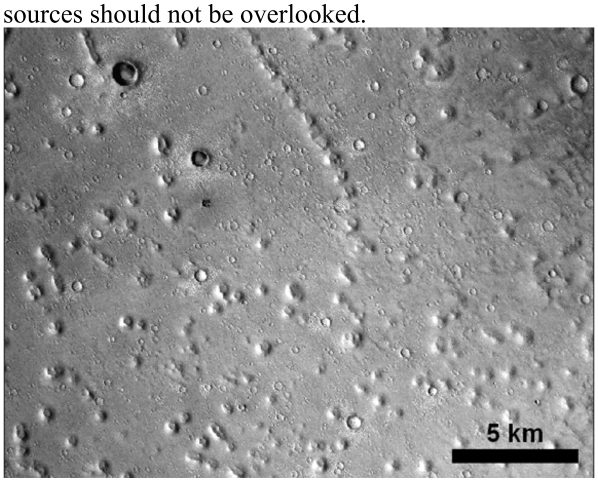

Fig. 4. Mounds in Isidis Planitia. CTX image.

Terra Sabae. The Terra Sabae region, which straddles the Arabia Terra region to the northwest and the Hellas basin to the southeast, is characterized by the presence of degraded craters and valleys. The methane emission may be related to the enriched near-surface hydrogen (or water) in the region [28], which includes an interaction among a hypothesized regional basin-aquifer system in Arabia Terra [29] and basement structures such as those induced by the Hellas impact event.

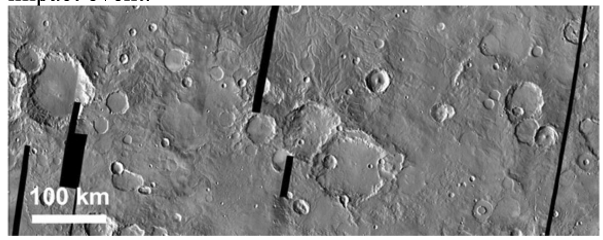

Fig. 5. Cratered terrain and valleys of Terra Sabae. THEMIS IR daytime image mosaic.

Conclusions: Our work highlights the need for further investigation of methane gas emission on Mars in regard to (1) the mechanism(s) of emission (e.g., possible serpentinization, decomposition of methane clathrate, or magma-driven activity including hydrothermal activity, as well as extant life) and (2) candidate vent structures (e.g., faults and fractures of Nili Fossase, calderas/lava plains of Syrtis Major, and mounds of Isidis Planitia), which includes extent (e.g., one or more and local vs. regional).

References: [1] Krasnopolsky V. A. et al. (2004) *Icarus*, *172*, 537–547. [2] Formisano V. et al. (2004) *Science*, *306*, 1758–1761. [3] Geminale A. et al. (2008) *PSS*, *56*, 1194–1203. [4] Mumma M. J. et al. (2009) *Science*, *323*, 1041–1045. [5] Geminale A. and Formisano V. (2009) *Workshop on Methane on Mars*. [6] Prieto-Ballesteros O. et al. (2006) *Geology*, *34*, 149–152. [7] Chastain B. K. and Chevrier V. (2007) *PSS*, *55*, 1246–1256. [8] Elwood Madden M. E. et al. (2007) *GRL*, *34*, L11202. [9] Chassefière E. (2009) *Icarus*, *204*, 137–144. [10] Ishimaru R. et al. (2010) *LPS XXXXI,* this volume. [11] Milton D. J. (1974) Science, 183, 654–656. [12] Ori G. G. and Baliva A. (1999) *LPS XXX,* #1758. [13] Ori G. G. et al. (2000) *LPS XXXI,* #1550. [14] Komatsu G. et al. (2000) *LPS XXXI,* #1434. [15] Kargel J. S. et al. (2000) *LPS XXXI,* #1891. [16] Ori G. G. et al. (2001) *LPS XXXII,* #1539. [17] Rodriguez J. A. P. et al. (2006) *GRL*, *33*, L18203. [18] McMenamin D. S. and McGill G. E. (2009) *LPS XXXX*, #1848. [19] Ehlmann B. L. et al. (2009) *JGR*, *114*, E00D08. [20] Oze C. and Sharma M. (2005) *GRL*, *32*, L10203. [21] Ivanov M. A. and Head J. W. (2003) *JGR*, *108*, E6, 5063. [22] Etiope G. et al. (2007) *JVGR*, *165*, 76–86. [23] Frey H. and Jarosewich M. (1982) *JGR*, *87*, 9867–9878. [24] Grizzaffi P. and Schultz P. H. (1989) *Icarus*, *77*, 358–381. [25] Bridges J. C. et al. (2003) *JGR*, *108*, E1, 5001. [26] Davis P. A. and Tanaka K. L. (1995) *LPS XXVI,* 321–322. [27] Etiope G. et al. (2009) *MPG*, *26*, 333–344. [28] Feldman W. C. *Science*, *297*, 75–78. [29] Dohm, J.M., et al. (2007) *Icarus*, *190*, 74–92.