EVIDENCE FOR DIKE SWARMS ON THE EASTERN HELLAS RIM, MARS. J. Korteniemi[1,2], J. Raitala[1], M. Aittola[1], M. Ivanov[3], T. Öhman[1,4], V.-P. Kostama[1] and H. Hiesinger[2]. [1]Department of Physical Sciences, University of Oulu, Finland <jarmo.korteniemi@oulu.fi>, [2]Institut für Planetologie, Westfälische Wilhelms-Universität, Münster, Germany, [3]Laboratory of Comparative Planetology, Vernadsky Institute of Geochemistry and Analytical Chemistry, RAS, Moscow, Russia, [4]Department of Geosciences, University of Oulu, Finland.

Introduction: Few studies have tackled the question whether significant magmatic intrusions, other than those forming volcanic edifices of the Paterae, have occurred in the old regions on Mars. Dikes have been speculated to exist on the grounds of magnetic anomalies on the southern highlands, regional ridge patterns and through analysis of various impact crater floors [1-4]. So far only one major magmatic dike system has been positively identified [5].

Large sections in the eastern sector of the 2000-km wide Hellas impact basin rim have been severely eroded. In order to account for this and the mobilization of subsurface volatiles during the various stages of the basin evolution, many researchers have modeled specific magma–ground water/ice interactions [e.g. 6-11]. This method of volatile mobilization is strongly supported by the existence of past volcanic activity in the region: Four large volcanoes sit on the basin rim, and much of the adjacent regions are covered by ridged lava plains [8-16]. Although the vast Circum-Hellas Volcanic Province (CHVP [17-18]) is comparable in size to Elysium, so far any evidence of actual interaction between ground water/ice and endogenic heat sources have been circumstantial. In addition, much of the above-mentioned vast plains have been interpreted to be fissure-fed lava plains on the grounds of a wrinkle ridged and layered structure. However, no dikes, lava flows or other direct evidence of a volcanic origin have so far been found [19-20]. Thus, positively identifying magmatic intrusions such as dikes in the Hellas region would help to understand the extent of the association between magmatic activity, subsurface volatiles and the surface features we see today.

In this study, we have systematically searched the eastern Hellas rim region for any signs of magmatic dikes, analyzed their characteristics, and hypothetisize on what controls their distribution and orientation (for more, see [21, in review]). Our study area, spanning roughly 700 by 1200 km (25–45°S, 87.5–102.5°E), covers much of the northern CHVP, including Hadriaca Patera, the plains of both the Hesperia Planum–Hellas trough and western Promethei Terra [10,16], the adjacent heads of Dao, Niger, Harmakhis and Reull-Teviot Vallis, as well as several occurences of Noachian highland terrains and massifs.

Methods and data: The region was surveyed for all types of surface manifestations of magmatic dikes. The following is a short list of the features, which are more thoroughly discussed in the accompanying abstract [22] and in [21]: 1) Linear / en-echelon fractures or shallow graben on the surface above the dike; 2) Pit chains or maars; 3) Surface vents; 4) Fissure-associated lava flows; 5) Near-vertical lineations in strata cross-sections; 6) Linear ridge outcrops of the resistant dike body itself. The survey was conducted using MEX HRSC images at 50 m/pixel [23-24]. Suspected dikes and adjacent regions were mapped at highest possible resolution HiRISE, MOC NA, CTX, HRSC and THEMIS images [23-28].

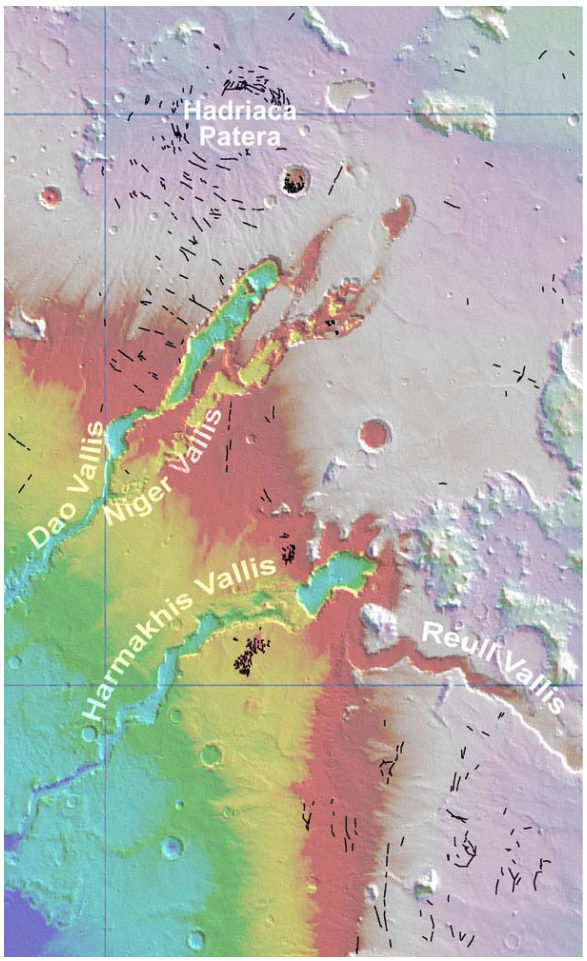

Fig. 1. Distribution of the identified dike segments (black lines) shown on MOLA topography map of the study region Hellas is towards the left. Figure modified from [21].

Results: In total, 500 dike segments were identified, with a combined length of ~2500 km. Roughly 90% of the dikes are exhumed linear ridges, suggesting that the entire region has undergone large-scale erosion. The remaining 10% are narrow grabens / fractures, occurring solely on the Hadriaca Patera volcano. All structure widths are several tens to hundreds of meters, and shadow measurements show that ridges are typically less than 40 m high. Superposition and cutting relationships put all the dikes within the study region roughly Late Hesperian in age, either predating the Valles formation or being concurrent with them.

Regional distribution: Dikes are observed in distinct groups in the region (Fig. 1): on the Hadriaca Patera volcano, on the plains south of it, in two tight groups on either side of the Harmakhis Vallis neck, and on the plains south of lower Reull Vallis. Detailed mapping of the key regions are available in [21].

Hadriaca Patera flanks exhibit a concentric pattern of linear ridges and fractures, indicative of a vast ring dike system embedded in the volcano. The dikes occupy mostly the area near the summit caldera and the Hellas-facing flank, in the latter extending for over 400 km away from the summit.

A fragmented and roughly radial N-S dike pattern is observed extending southwards from Hadriaca Patera. It consists of several linear ridge group outcrops that are apparently cut by the Valles formations. An additional N(NE)-S(SW) ridge group exists south of lower Reull Vallis. It is topographically isolated from any Hadriaca-related near-surface magma chambers, and may instead be controlled by Tyrrhena Patera some 1300 km away.

Discussion and conclusions: The two young and prominent volcanic provinces on Mars, Tharsis and Elysium, are surrounded by vast graben networks, suggested and subsequently proven to be caused by magmatic subsurface dikes and (giant) dike swarms [29-42]. The current study identifies similar patterns of probable dikes on the eastern Hellas rim, thus strengthening the idea that the basin region harbors an additional ancient large volcanic province [17-18]. Comparable to the dike patterns around the large volcanoes on Tharsis and Elysium, the concentric dikes on Hadriaca and the radial dikes south of it most probably relate to magma chamber(s) below that volcano. Interestingly, the fact that almost all of the dikes on the plains south of Hadriaca are N-S oriented also hints towards a Hellas-concentric fracture pattern, which would have acted as an easy route for the propagating dikes. These fractures probably result from the impact event, which has been shown to cause very long-lasting stress patterns throughout the adjacent regions [43]. The dikes are mostly ridges, i.e. exhumed dike bodies, indicating that much of the surface of the entire region has undergone significant erosion, removing at least several tens of meters of material.

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