RELATIONSHIP BETWEEN NAKTONG VALLIS' HEADS AND INTERCRATER PLAINS: SUSTAINED OF FLUVIAL ACTIVITY EXTENDING DURING THE HESPERIAN. S. Bouley [1] V. Ansan [1] N. Mangold [1] Ph. Masson [1] and G.Neukum [2]; [1] IDES – University Paris Sud – 91405 Orsay – France; [2] Deutsches Zentrum für Luft- und Raumfahrt, D-12489 Berlin, Germany. (sylvain.bouley@u-psud.fr)

Introduction: The morphology of fluvial valleys on Mars provides insight into surface and subsurface hydrology as well as past climate [1]. Naktong Vallis, located in the southern highland, has different kinds of heads, which are generally amphitheatres. Nevertheless the dendritic organization suggests that Naktong Vallis is certainly a combination of runoff and sapping processes or that it attained a mature stage of development of seepage erosion. Heads of Naktong Vallis are located in different intercrater plains which formed at different epochs of Hesperian. Relationship between these valley heads and plains show that fluvial activity was present during all the Hesperian at least episodically.

Data Set: The images of High Resolution Stereo Camera of Mars Express allows us to study Naktong Vallis with high resolution (15m/pixel) and large coverage. These images give us the general organization of valleys belonging to Naktong Vallis, details of the morphology of valley heads the relative age of different observed intercrater plains in counting craters up to 1 km diameter. Additionally, we used digital topography from MOLA at a resolution of 460 m/pixel which allows us to know the morphology of valley and valley heads.

Naktong Vallis: Naktong Vallis (Fig. 2) is located on the southern highland plateau on the south of Arabia Terra. Naktong Vallis, oriented N-S and long of 1200 km has its head is on Terra Sabae (4°S, 38°E) and debouched north of Arago crater (10°N, 30°E)(Fig.1). This valley with an average slope around 0.1° has a constant width around 4 km and a depth around 200 m which increases with the distance from the head. It is connected to few tributaries which presents a dendritic organization. The total length of 383 tributaries of Naktong reaches 4616 with 5 Strahler's orders [2]. The total basin covers 264 000 km², which implies a drainage density of $7.6.10^{-3}$ km^{-1}.

Relationship between Naktong Vallis and intercrater plains: Figure 1 shows a map of the different observed intercrater plains. The nature and origin of these plains remains uncertain. They present a smooth texture and exhibits compressional wrinkle ridges [3]. The properties of the plains are consistent with either a volcanic, subaqueous or subaerial sedimentary deposits [4]. We observed two kinds of intercrater plains. (1) Green intercrater plains are incised continuously by the valley. The valley formed or had an extended activity after the formation of these plains. The fresh crater counting of Terrains I, II and III located on these plains is around 4000×10^{-3} $craters.km^{-2}$, corresponding to the Early Hesperian period [5].

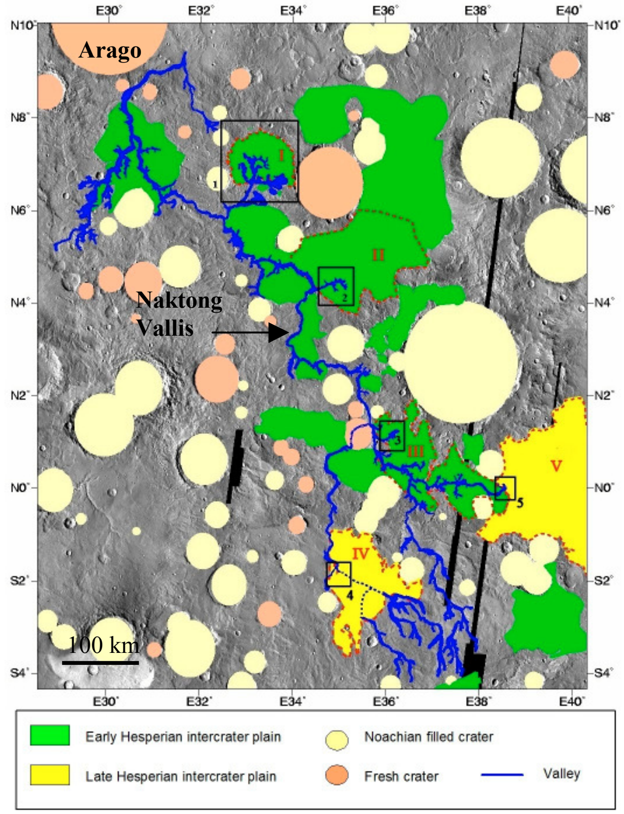

Figure 1. Map of early and late hesperian intercrater plains. Terrains I to V (red dotted line) and HRSC images 1 to 5 location (black square).

(2) Some tributaries are covered by the yellow intercrater plains. Indeed, valleys south to the yellow plain IV cross a terrain older than the yellow plain and are apparently buried by the plain IV. We don't observe continuous valleys on these plains. Terrains IV and V present N(1) around 2900×10^{-3} $craters.km^{-2}$ corresponding to the Late Hesperian epoch [5] (Table 1) and are relatively younger than terrains I, II and III. Nevertheless, a doubt subsists on the age of valley formation because we observed that valley heads are close to the limit of the yellow intercrater plains. The study of

the morphology of valley heads in both types of plains might help to understand better their relationships.

Terrains	A(km²)	N	N(1)	+/-error
Early Hesperian Pre-valley intercrater plains				
I	6546	26	3971	778
II	13117	53	4040	555
III	11198	46	4107	605
Late Hesperian Post-Valley intercrater plains				
IV	17500	52	2971	412
V	6628	19	2866	657

Table 1. N(1) $\times 10^{-3}$ craters.km^{-2}

Morphology of valley heads: Figure 2 shows 5 different heads of Naktong Vallis (black squares on Fig. 1). These five heads have different geometries and some similarities. We observed that morphologies are blunted because of the dust which covered the major part of the region. In all cases, heads appear to incise flat and smooth terrains, which are intercrater plains(Fig.1).

Images 1, 2 and 3 on figure 2 located respectively on terrains I,II and III show valley heads in large amphitheaters. Valleys are initially wide (~1km) and deep(~100m). We observed that width is constant far from the head too. For each case, the number of amphitheaters is important.

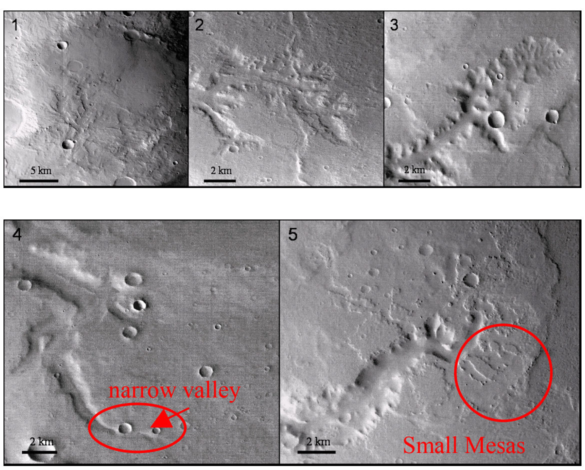

Figure 2. HRSC Images 1, 2 and 3 show heads formed by seepage erosion. Images 4 and 5 show head formed by a combination of surface and seepage erosion

Image 4 and 5 in Terrains IV and V present different head geometry. We observed only one or two amphitheaters. The width of the valley increases with distance from the head (less than 1 km at the valley head and up to 3 km ten kilometers far from the head). Moreover we observe surface erosion on the plateau up the amphitheaters. Image 4 shows a very narrow and superficial valley before the amphitheater. On the image 5, we observed small superficial mesas on the plateau up the valley's head.

In summary, we observe that the morphology of heads 1 to 3 and heads 4 and 5 are slightly different. We can suggest that the processes having formed them or their duration of activity were different. The fact that Terrains I, II and III are older than terrains IV and V is consistent with the fact that we observed more developed valley heads on Terrains I,II and III. We can conclude that valley heads 4 and 5 cut the edge of Late Hesperian intercrater plains, so that there has been an activity posterior to these plains.

Conclusion: The majority of valley networks in the southern highlands formed during the Noachian period [e.g. 1], and Naktong might have been initiated at that time too. However, our observations show a strong post-Noachian evolution. First, Naktong network developed after the formation of the green plain of Early Hesperian age as shown by their crosscutting relationships. Second, a post yellow plain (of Late Hesperian age) activity is also possible from the crosscutting relationships with the valley heads in these plains. Nevertheless, the fact that valleys do not cut continuously these yellow plains suggests this later activity was much lower than the one previous to the yellow plain formation. In all the cases, the crosscutting relationships between valley heads and intercrater plains of Early Hesperian and Late Hesperian age, we can conclude that a fluvial activity existed at least until the Late Hesperian (>3.2 Gyr). In previous studies [e.g. 6,7], erosion during Hesperian was suggested but the climate was usually thought to have been cold and dry. The development of Naktong Vallis during the Hesperian epoch suggest sustained liquid water was still possible during that period.

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