UPSTREAM MATERIAL ACCUMULATION AND MEANDERING ON PRESENT DAY GULLY EVOLUTION. K. Pasquon, J. Gargani, M. Massé, S.J. Conway, M. Vincendon, and A. Séjourné. GEOPS, Univ. Paris-Sud; CNRS, University Paris-Saclay, rue du Belvédère, Bat. 504-509, 91405 Orsay, France (kelly.pasquon@u-psud.fr, julien.gargani@u-psud.fr, antoine.sejourne@u-psud.fr). 2LPGN, University of Nantes UMR-CNRS 6112, 2 rue de la Houssinière, 44322 Nantes, France (marion.masse@univ-nantes.fr, susan.conway@univ-nantes.fr). 3IAS, Univ. Paris-Sud, CNRS, University Paris-Saclay, rue Jean-Dominique Cassini, 91440 Bures-sur-Yvette (mathieu.vincendon@u-psud.fr).

Introduction: Since their first observation by Malin and Edgett (2000) [1] martian gullies have been abundantly studied, but their formation mechanism is still under debate [e.g. 2, 3, 4, 5, 6]. Gullies are generally composed of an alcove, a channel and an apron [1, 7] and some of them are active today [8, 11]. They present sometimes sinuosities and infrequently meanders. Meanders are an intriguing morphology on Mars because they are known to involve liquid water on Earth. Here we describe the present day evolution of a meandering gully on Mars, located on the sand dune of the Matara crater (49.5°S, 34.7°E) (Fig. 1).

The aim of this study is to answer two main questions:

i) How sand material accumulation in the alcove influence the meandering gully evolution?

ii) What process can explain the present day formation of meanders?

Method: This study was performed using:

1) HiRISE images at 25-30 cm/pixel: We performed our survey of meandering gully by inspecting all the HiRISE images available. Morphological differences between images were identified by manually georeferencing the images locally.

2) 1 m/pixel HiRISE elevation data (DTM): Slope measurements and cross sections were performed on the active areas of the gully and over the surface of major interest.

3) Temperature model: We performed a 1D model (GCM) to estimate the temperatures on the dune surface at a 0.5h step.

Observations: The meandering gully is composed of an alcove, a channel, and an apron. It is 2700 meters long and is extremely active during the last 4 martian years. This gully is observed on a moderate mean slope (~13°), on a dune oriented towards the east. Each year, we observed material transport from the alcove to the apron (Fig. 1). Three main morphological changes are observables:

i) a sand accumulation can be observed in the alcove. Slope process oriented toward NNE transport non negligible amount of sand material. During the last 4 martian years, the total amount of material transported is more than 13 000 m². This activity seems not seasonal.

ii) a mass transport deposits trigger seasonally the growth of meanders, the extension of the channel, and the elongation of the apron (Fig. 2). Over one martian year the debris apron elongated by almost 150 meters from an initial size of 900 meters. The activity of the mass transport deposits occurs each year during winter between Ls 117.6° and Ls 180.8°. Mass transport deposits are observed when surface temperatures oscillate between 165K and 238K (Fig. 3). During this period of time CO₂ frost is still present and seems to just begin to defrost.

iii) linear gullies and isolated pits creation appear at the end of winter and in the beginning of spring, between Ls 176.4° and Ls 199.8°. Linear gullies and pits are visible when temperatures range between 215K and 258K (Fig. 3). These activities can be observed when the seasonal defrosting is coming to an end.
Fig. 2. Mass transport deposits activities. A) B) Digging and filling of channel at the bottom of the alcove (ESP_037965_1300 Ls 188.6° and ESP_028972_1300 Ls 180.8°). C) D) Digging of meanders on the channel (ESP_006648_1300 Ls 8.8° and ESP_037965_1300 Ls 188.6°). E) F) Elongation of the apron (ESP_034009_1300 Ls 41.8° and ESP_037411_1300 Ls 164.5°).

Fig. 3. Modeled surface temperatures on the Matara dune fields (49.5S; 34.7E) for pole facing slopes of 13° with a time step of ½ hour during one martian year.

Discussion:
Solid material accumulation in the alcove and gullies evolution:
The meandering gully activity can be separated in 3 main phases: 1) Sand material is accumulated in the alcove on the equator facing slope all along the year (not seasonally), 2) Seasonal frost is deposited on pole facing slopes in autumn and winter, 3) Sudden defrosting of seasonal deposits occurred after mid-winter and triggered the transport of material toward the debris apron as well as the development of meanders.

Present day formation of meanders:
Several processes seems to disagree with a purely dry mechanism: 1) The slope of the gully is too low (16° in the upper part of the meandering gully; mean slope of 13°) and smaller than the sand friction angle, 2) the presence of meanders that is known to be associated with fluid processes, and 3) a white halo that can be observed around the apron.

Seasonal deposits on the studied gully are composed of CO₂ and water [9]. The temperature is too low when the mass transport deposits occurred to argue for liquid water. At the opposite, gully activity occurred every year when CO₂ begin to defrost. CO₂ as an agent of topographic change has been suggested by recent laboratory experiments which showed that small amounts of CO₂ frost deposited into a granular medium can cause granular flows on slopes >13° under terrestrial gravity [10]. However, it is not known how CO₂ sublimation could create meanders in the channel. Complex processes could perhaps explain this phenomenon.

Linear gully and pits are observed later and could be related to CO₂ gas activity but also to a process involving the presence of brine [11].

Conclusion:
The present day evolution of this spectacular meandering gully is formed following three different phases: 1) Sand material accumulation (not seasonal) occurred on the alcove. 2) Seasonal frost deposits, composed of CO₂ and water, can be observed on pole facing slopes in autumn and winter. 3) Sudden defrosting of seasonal deposits during the middle of winter triggers the sand transport. CO₂ gas is the best candidate to explain the present day creation and development of meanders on Mars as well as the significant sand material deposit on the debris apron.

References: