COMPOSITION OF ALLUVIAL FANS AND DELTAS ON MARS. J. Carter[1,2], F. Poulet[1], N. Mangold[3], V. Ansan[3], E. Dehouck[3], J.-P. Bibring[1], S. Murchie[4]. [1]IAS, Orsay, France. [2]ESO, Santiago, Chile. [3]LPGN, Nantes, France. [4]APL, Laurel, MD, USA. John.carter@ias.u-psud.fr

Introduction. Alluvial fans and deltas are morphological features recording dilute or dense fluvial flows in a sub-aerial and sub-aqueous environment, respectively. A number of them have been identified on Mars, dominantly within impact craters which provide natural sedimentary sinks for the flow (e.g. *Kraal et al., 2008, Ansan et al., 2011*), or more rarely at the topographic dichotomy and along other scarps (e.g. *Di Achille et al., 2010*). Most of the intra-crater fans have been proposed to have a fluvial origin in an arid surface environment (*Moore and Howard, 2005, Armitage et al., 2011*), either fed by localized snowmelt and precipitation or connected to dendritic valley systems (such as the Jezero, Holden or Ismenius Cavus deltas, *Ehlmann et al., 2008, Milliken et al., 2009, Dehouck et al., 2010*). The mineral composition of the deltas and fans should reflect this fluvial origin, either by the accumulation of detritral clays which are widespread in the Noachian source regions (e.g. *Carter et al. – this conference*) or by the formation of authigenic clays and salts during the deposition (e.g. *Milliken et al., 2009*). While detrital clays (and at time salts) have been identified in selected deltas and fans on Mars (including Eberswalde, Jezero, Holden and Terby), few systematic survey of their composition have been carried out (*Hughes et al., 2012*). We present results of a mineralogical survey of all fans and deltas on Mars as seen by the CRISM imaging spectrometer.

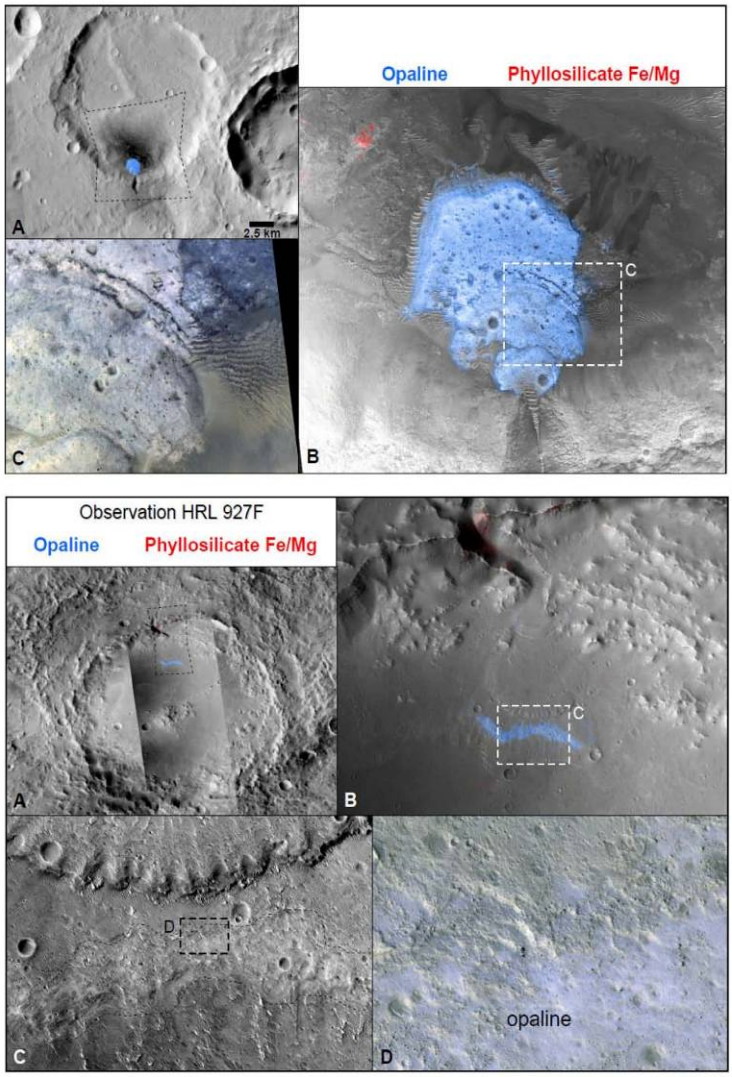
Sample selection. We retrieved all high resolution (< 36 m/pix) CRISM observations of fans and deltas identified in previous morphological studies (inc. *Kraal et al., 2008, Di Achille et al., 2010*), and additional targets acquired by the CRISM team, then processed the data in search for hydrated minerals. A final sample of ~30 fans/deltas was selected after rejecting low S/N and high surface dust / aerosols observations. This represents the majority of un-ambiguous fan/delta structures found to-date on Mars, and should increase slightly as new CRISM targets are observed.

Mineral composition. Out of the 30 fans, 24 presented un-ambiguous hydrated mineral signatures, 22 of which presented opaline silica. Accounting for the limitation of orbital remote sensing (some opal detections are barely resolved with CRISM) and the only partial coverage of some of the fan structures, it appears that opal is the dominant hydrated phase found in fans/deltas, followed by Fe/Mg clays. The opal units within the fan deposits all exhibit a smooth morphology which contrasts with the remainder (non-opal bearing) of the fan structure. To the exception of one site (fig. 1A), opal only partially covers the fan/delta and is predominantly found in its distal part (fig. 1B). While the smaller fans are dominated by opal, the largest deltas all exhibit opal but are spatially dominated by Fe/Mg clays (Terby, Jezero, Holden and Eberswalde), suggesting a different depositional scenario. Opal is also present in other geological contexts: chaos, horizontal plain deposits, associated with putative acid-weathering sequences, and in hydrothermal systems (impact generated systems in the central peak and volcanic units), as shown in fig. 2A.

Fan ages. The preliminary age of the deltas and fans was determined using a low spatial resolution geological map of Mars (*Scott and Tanaka, 1986*), pending more precise dating. The fans postdate the age of the crater in which it is found, which in turn can postdate the age of the geological unit which is dated. Fan ages are therefore a coarse upper estimate and will not be independent of the evolution of the production function of impacts through time. Accounting for this bias, we find a dominantly Hesperian age for most of the opal-bearing fans (fig. 2B), which contrasts with a dominantly Noachian age for the other hydrated minerals on Mars.

Interpretation. Opal is typically found on Earth in arid/acid environments while alteration under wetter conditions (higher W:R ratio) produces zeolites and smectites, and opal becomes unstable (*Tosca and Knoll, 2009*). Its presence in almost every fan on Mars suggests limited aqueous activity under a dry climate, in accordance with predictions for the Hesperian climate. Opal is never seen as the sole alteration product in crustal outcrops of Noachian age. It is therefore unlikely that the opal in fans are a detrital product transported from a Noachian source region, opposite to the detrital clays found in the major deltas on Mars. We propose an in-situ origin for these opal exposures, either formed directly within the fan during deposition or at times formed during the drying out of the sediments (e.g. lake level variations), or possibly as coatings or silcretes at the surface of the deposited material during their cementation. These detections indicate that the formation process of fans on Mars albeit in a arid environment, involved limited surface water flow, ponding, and chemical alteration at the surface.

Figure 1. (A) Intra-crater alluvial fan entirely composed of opal silica with a small pocket of Fe/Mg smectite. (B) Typical intra-crater fan opal detection: opal is found in a smooth unit in the distal part of the fan. CRISM footprints are in dotted lines. Backgrounds are THEMIS, CTX and HiRISE images.



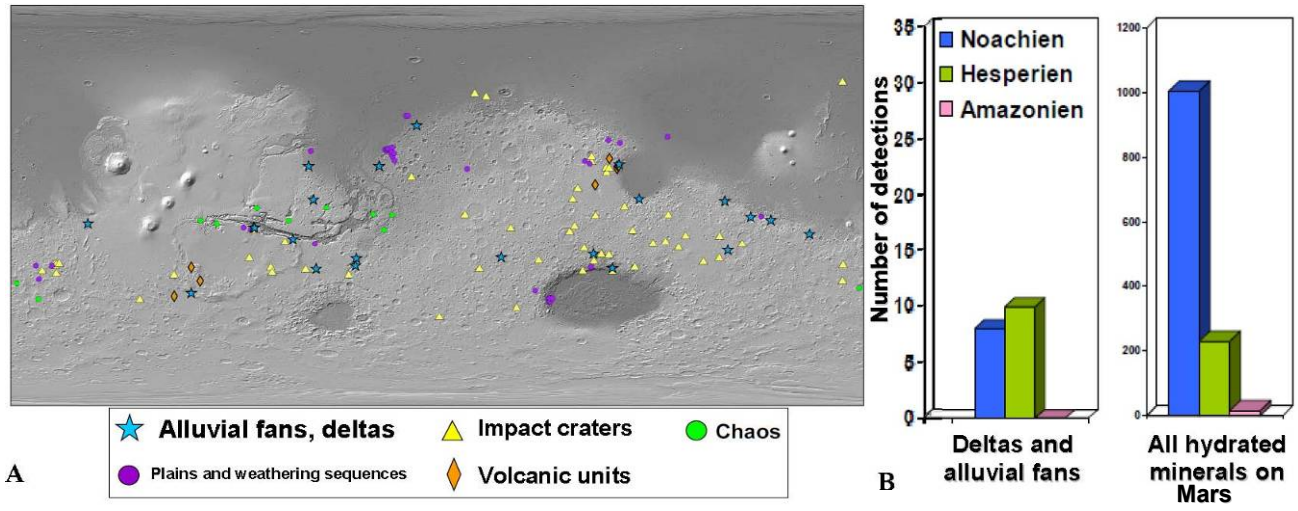


Figure 2. (A) Global map of opal detections on Mars according to context. A few detections marked as 'impact craters' were later found to be part of an intra-crater alluvial fan, the remainder being central peaks. (B) Age-frequency of the opal-bearing alluvial fans and deltas on Mars compared to the age-frequency of all hydrated minerals on Mars (over a thousand exposures).