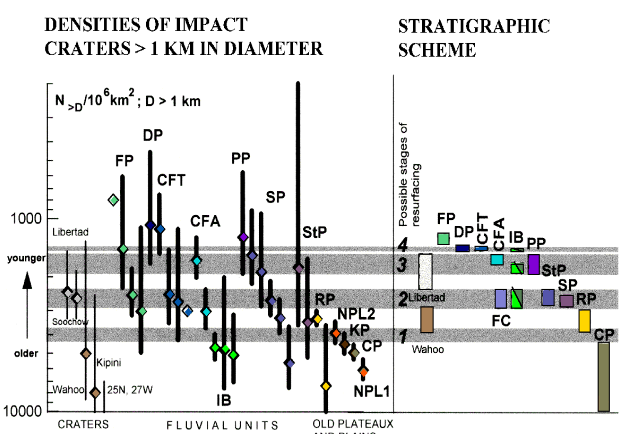
THE STUDY OF THE MOUTH OF ARES AND TIU VALLES, MARS. A. G. Marchenko[1], A. T. Basilevsky[1], G. Neukum[2], E. Hauber[2], H. Hoffmann[2], A. C. Cook[3], [1]Vernadsky Institute, Russian Academy of Sciences, Kosygin Str. 19, Moscow, Russia 117975, abasilevsky@glasnet.ru, [2]DLR Institute fur Planetenerkundung, Berlin, Germany, [3]National Air and Space Museum, Washington DC, USA.

Introduction.

The Mars Pathfinder landing site is within the mouth of Ares and Tiu Valles. The most popular hypothesis for explaining the formation of valleys of this class is by the catastrophic outflow of gigantic volumes of liquid water. However many questions concerning their formation still have to be answered. For the understanding of regional and local geology we studied all available Viking Orbiter images of the large region covering the confluence of the outflow Ares and Tiu channels, including the Pathfinder landing site [1-6]. A geologic map for this area has been made [10].

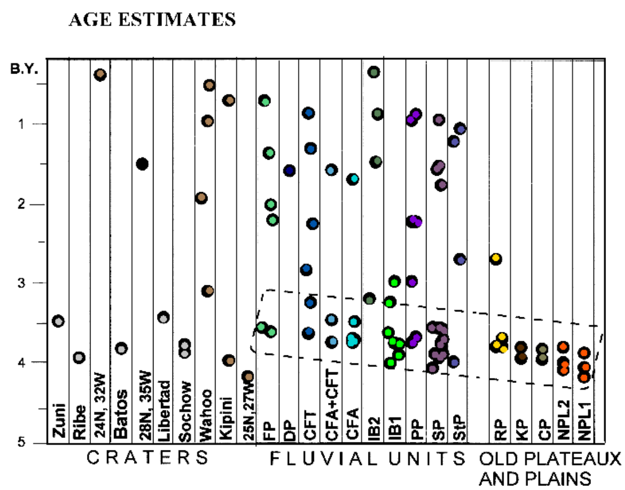
Photogeological analysis revealed units which represent: highlands materials, fluvial deposits of Tiu and Ares Valles deltas and channel floors, and impact crater materials. A study of the age relations of the units allows us to suggest the following scenario for the geologic history of the region. After the emplacement of the old plateau material (CP) it was heavily eroded forming knobby plateau (KP) and hills (H), and partly covered by plains material with wrinkle ridges (RP). The first outflow event formed small throughs (FC), high terrace levels in the valleys (IB1), and delta deposits (StP and SP). The next flood episode formed probably the presently observed floor of Ares Vallis channel (CFA) and the younger component of delta deposits (plains with numerous pits, PP). During the younger outflow event the present floor of Tiu Vallis (CFT and DP) formed. Then plains material characterized by sinuous depressions, ridges and fractures (FP) emplaced in the northern part of the area. Thus, fluvial activity within the Ares and Tiu mouth area seems to have occurred in four major stages of resurfacing: one pre-valley stage and three subsequent stages of valley-related erosion and associated deposition.

Figure 1.



Analysis of impact crater size-frequency curves showed that: 1) the old plateau is of Noachian age, Ares Vallis is Hesperian and Tiu Vallis is Late Hesperian - Early Amazonian, 2) the multi-stage geologic history of this area has been deduced using photogeologic observations, supported by the crater counting results. The latter is illustrated in Fig. 1 in which the results of crater countings for different units are shown on the left side and stratigraphic relations between these units on the right side. The positions of the grey horizontal bands mark possible positions of resurfacing events and were deduced from the observations and measured crater densities.

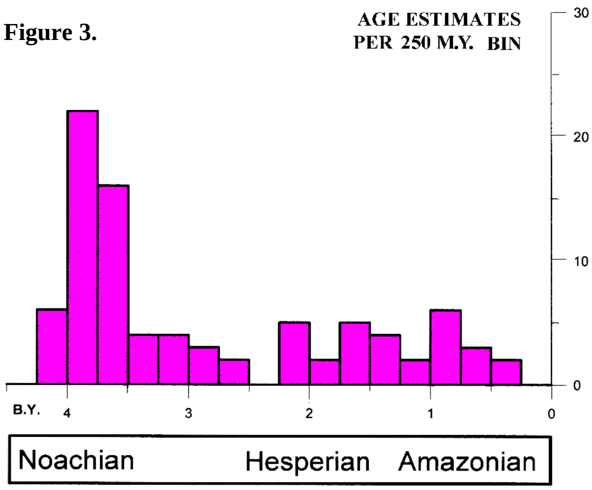
Figure 2.



Absolute dating of the mapped units was made using the results of our crater countings, and the Martian standard curve [7-8]. For the sites where the crater counts were done, the shape of the crater size-frequency curves typically do not correspond to the "normal" shape of the simple crater size-frequency production curve. For the majority of the sites, the curves have bends which were considered to be characteristic of additional episode(s) of partial resurfacing of the area [7]. The method used allows us to estimate the model absolute age for time of formation and time of partial resurfacing within the unit. This work has been undertaken for different geological units, and different parts of specific individual units. The results of the dating are illustrated in Fig.2., and on the whole it shows clearly a wide interval of ages, from 4.25 to 0.5 b.y. For some individual geologic units the diagram also shows a large scatter of the ages. This scatter is evidently the combined effect of: (1) stochastic variations due to random errors in sites containing relatively few craters and (2) records of more than one episode of the resurfacing as indicated in the above mentioned bends in the crater curves.

Because of relatively small areas of the studied units the one-sigma error bars are large for most crater counts (see fig 1).This leads to even greater uncertainty in age estimates. So, any individual value of age taken per se on Fig.2 has large uncertainty (not shown here) due to random errors and so geologically-meaningful conclusions based on any one of these individual values are risky. However, because the errors are random, they should statistically compensate each other. If so, signatures of the individual resurfacing episodes should form clusters centered at the true ages of these episodes. On the diagram shown on Fig.2, two clusters can be seen: a distinct one, centered at about 3.7 b.y. (shown by dashed line for all units except impact craters) and another, less distinct one, centered at about 1.5 b.y. This suggestion finds support in the fact that the units, which were determined to be the oldest by photogeological observations (KP, CP, NPL1 and NPL2) show ages only within the first cluster, and the values are biased to its older part (4.25-3.75 b.y.). Most of the units which were determined to be relatively

Figure 3.



young, or affected by the later episodes of resurfacing (StP, SP, PP, IB1, CFA, CFT, DP, and FP), show ages within both clusters. The unit RP, which is considered to be intermediate between these two groups by photogeologic observations, is characterized by four age estimates three of which belong to cluster 1 (biased to its center) and one estimate is in between the two mentioned clusters. The histogram of Fig.3 was made on the basis of absolute dating too. Clusters appear as peaks here. So, it is possible to suppose that they roughly correspond to age values of main episodes of recurfacing. The results suggest that the most prominent resurfacing episodes occurred around 3.9+/-0.2 and 3.7+/-0.2 b.y. ago. Weaker but still prominent flooding stages are observed from 2.0-2.25 and 1.5-1.75 b.y. The crater counts provide further strong hints at additional but minor resurfacing episodes around 3.0+/-0.2 and 0.75- 1.0 by.

It is necessary to say, that the SE part of the area under study, where the group of the oldest units is localized, is covered by the low-resolution images only, while for the sites of the younger units medium resolution images exist and were were used for the crater counts. However, we beleive that this difference in the image resolution can not be the reason for the observed distribution of age estimates among the geologically older and younger units. The worse image resolution for the older units, if it would affect the age esimates, should bias the results to the younger, in fact exactly opposite to what be required by the data obtained. So, we beleive that the effect of difference in the image resolution does not change drastically the deduced age distribution pattern.

The results presented on Figs 2 and 3, and the above consideration of them, can be interpreted as evidence that the oldest units of the area under study (KP, CP) formed evidently about 4 b.y. ago and within the relatively short period of time they were resurfaced with the formation of Ridged Plains (RP). Between 3.00 and 3.75 b.y. ago, fluvial and other water-related (glacial?) activites formed a series of the channel and channel-associated units. These later units then were resurfaced by new episode(s) of fluvial activity which happened about 1.5-2.25 b.y. ago and possibly by even later episode(s) (0.75-1.0). These later episodes of resurfacing might be fluvial, but eolian or thermokarst reworking also are possible.

Neukum and Hiller [7] estimated ages of 3.65-2.5 b.y. for Ares and 3.5-2.0 b.y. for Tiu that roughly correspond to our first two ages of fluvial resurfacing. Also these two ages are in general agreement with the work of Robinson et al. [9]. Several segments of Ares Vallis, including the described area, were studied in that work. Based on crater counts, previous authors have shown that the major period of the channel formation lasted until 3.5 b.y. ago and that later resurfacing events occured between 2.21 and 1.66 b.y. ago. Robinson et al. [9] suggested that this later resurfacing was probably volcanic, however our interpretation suggests it seems to be mostly fluvial.

Thus, estimates of absolute age suggest two to four major episodes of resurfacing at the Mars Pathfinder landing site and its vicinites. The results of this study provide a regional context for the analysis of Mars Pathfinder data.

References. 1. Marchenko A.G., The 24th International Microsymposium on Planetology (abstracts), P 62-63, 1996. 2. Marchenko, A.G., Basilevsky, A.T., Neukum, G. and Hoffmann H., Annales Geophisicae Pt III, 14, Suppl III, P C792, 1996. 3. Marchenko, A.G., Basilevsky, A.T., Neukum, G., Hauber, E., Hoffmann, H. and Cook, A.C., LPSC XXVIII, P 865-866, 1997. 4. Marchenko, A.G. et al., Annales Geophisicae Pt III, 15, Suppl III, P C768, 1997. 5. Marchenko, A.G. et al., The 26th International Microsymposium on Planetology (abstracts), P 79-80, 1997, 6. Marchenko, A.G., et al., *The mouth of Ares Vallis, Mars: Geology, stratigraphy and crater counting*, Paper in preparation. 7. Neukum, G. and Hiller, K., JGR 86, P 3097-3121, 1981. 8. Neukum, G. and Wise, D.U., Science 194, P 1381-1387, 1976. 9. Robinson, C.A., Neukum, G., Hoffmann, H., Marchenko, A., Basilevsky, A.T., and Ori, G.G. LPSC XXVII, P 1083-1084, 1996. 10. Waehlisch, M., Hoffmann, H., Jaumann, R., Neukum, G., Lehmann, H., Scholten, F., Albertz, J., Marchenko, A.G., and Basilevsky, A.T., The 26th International Microsymposium on Planetology (abstracts), P 129-130, 1997.