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The Kasei Valles were explored to establish to what extent the morphologic signature and lay of the land were compatible with formation or modification of channel features by water or ice processes. All available images and geologic and topographic maps were used for the study. Even though the error of the topographic maps is evaluated to be on the order of ± 1 km [1], only regional slopes over long distances were used, giving information of a very general nature. Thus, the gradients used are very approximate, but they nevertheless give an indication of the overall situation. Quantitative evaluation shows that discharges must have been extremely large if the channels were formed by floods. Lesser discharges would be needed if the erosional forms were sculpted by ice.

Morphology. The Kasei Valles apparently arise from Echus Chasma, but the actual channel showing streamlined forms and fluting, attesting to a moving fluid, only starts at lat 12° N. Upstream (south) of this latitude is chaotic terrain [2], similar to that of the other Chryse channels, but partially drowned by lavas from Tharsis. This chaotic terrain appears on the valley floor near the 4-km contour on the adjacent plateau, similar to the situation of the other peripheral Valles Marineris troughs [3].

For about 500 km below the chaotic terrain, the Kasei Valles parallel the regional slope in a strike or structural valley formed between the Tharsis volcanoes to the west and the scarp delineating the Lunae Planum plateau to the east. The apparent gradient is 0. The gradient steepens to near 0.005 only where the Kasei Valles bend to the east, break through the highlands of the Lunae Planum Plateau and the Chryse Basin rim, split into two (the north and south) channels, and become incised to about 1-2 km below the adjacent valley floor. Below and beyond the bend the gradients are again extremely low (about 0.0005 over 1500 km).

Kasei Valles had at least two flow episodes, and the surface was lowered by about 1 km between these episodes [2, 4, 5, 6,]. This erosion affected the Lunae Planum Plateau and Tempe Terra region, where the Kasei Valles cut through the highlands, and formed Labeatis Mensae. Both a fretting process and river erosion may have lowered the land in this region. The lower erosional platform upstream from the break through the Lunae Planum highlands is intensively scoured, showing longitudinal grooves more than 40 km long in places, 300 to 500 m wide, and 30 to 200 m deep (from shadow measurements) across a valley width of 100 to 300 km. These grooves extend into the northern incised channel, marking its walls and floor continuously without cut-and-fill structures. Apparently, the flow episode that eroded this platform also carved the 1-km-deep incised channel. Shadow measurements, photoclinometry, and eroded crater rims show that erosional scour on this platform may have been as much as 600 m deep and that the eroding fluid was at times at least 200 m deep when considering the size and depth of the grooves that must have been overtopped by the fluid.

Discharges. The Kasei Valles generally are considered to have been formed by cataclysmic floods [7]. Velocities and discharges of flood waters are difficult to calculate because assumptions concerning the water-surface gradient, the precise depth and width of the fluid (the wetted channel perimeter), the Manning coefficient, etc. have to be made. Here the equations for velocity and discharge used by Carr [8] and Baker [9] were applied to facilitate comparison with earlier reports. We used a Manning coefficient of 0.04 in keeping with Baker's [9] value for the Missoula flood and channels on Mars. Lower Manning coefficients would increase the discharge volumes. The value of 0.01 given by Baker [9] for the Mississippi River, if used for the Kasei Valles, would increase the discharges by a factor of 4.

The gradient of the Kasei Valles is near 0 above the gorges where the channels cut through the Lunae Planum and Chryse Basin rim highlands, and the Kasei Valles may have been a lake before the water broke through this at least 1-km-high barrier. Using a gradient of 0.001 (from the upstream margin of fluted valley floor to the mouth of the Kasei Valles, 2500 km downstream) and a minimum 200 m water depth, the velocity would have been about 15 m/sec. Assuming a 100-300 km width of the channel, the discharge would have ranged from 3×10^8 to 9×10^8 m^3/sec. For a 200-km-long section of the incised, more rapidly dropping channels (water depth 1000 m, width 20 km, gradient 0.005), the velocity would have been near 90 m/sec and the discharge 1.8×10^9 m^3/sec. (This water depth was used because the scour inside the incised north channel shows no cut and fill structures, indicating that flow was not interrupted during channel formation.) This velocity value compares with that of 32 to 75 m/sec (depending on the Manning coefficient used) and a discharge of 1.4×10^9 m^3/sec calculated by Robinson and Tanaka [10] for a section of the incised

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north channel, using different slope, depth, and width parameters. These discharge values are one to three orders of magnitude higher than those of the Missoula flood and one to two orders higher than those calculated for other outflow channels [9]. The higher values for Kasei largely derive from the greater channel width and water depths used in the calculations.

Source areas and discharge times. Release of water corresponding to one-half of Carr's [11] volume of the source area in Echus (535,000 km^3) would have furnished a flood of 49 hours duration [10]. However, the volume of Echus may have been only about 150,000 km^3 (depth 4 km) according to more recent maps [1], reducing the flow duration to just a few hours. When adding the Kasei Valles chaotic terrain (about 250,000 km^2, estimated depth 1 km), another 250,000 km^3 of water could have been available, for a total volume of around 400,000 km^3. Using a discharge of $1x10^9$ m^3/sec and assuming that the entire source region emptied in one event, water would have flowed for only 4 to 5 days. As water may also have come from the region of the Tharsis volcanoes before some of the Tharsis shields were built [6], water released from an area of 7,000,000 km^2 (a circle of 3000 km diameter, extending from near Echus Chasma to near Olympus Mons) might have been added to the flow. If all the possibly existing water was extracted from this region, equivalent possibly to a 100-m-deep layer of water (based on the assumed global water budget), an additional 700,000 km^3 of water could have been added to the Kasei Valles drainage. The latter estimate is extremely generous. According to these release volumes, flow could have lasted an additional 8 days. All of these values are maxima. Realistically, the water released from these various sources was no more than one-half of the above discharge estimates and probably much less, considering that sediments were almost certainly mixed with ice and water in the source areas.

Discussion. Enormous discharges are needed to satisfy the constraints posed by the channel dimensions and other morphologic features of the Kasei Valles system. Even though the characteristics and elevations of the source region are similar to those of other channels, permitting artesian heads and thus supporting Carr's [8] hypothesis of release from confined aquifers, it is difficult to envision that such quantities of water were liberated from the ground nearly instantaneously [12]. Lakes could have formed in Echus Chasma and in the chaotic terrain, releasing major floods, but, as in other chaotic terrains giving rise to channels, evidence for a broken dam is missing [13]. The postulated floods, lasting at best for a few days, carved 1-km-deep incised channels and removed at least as much as 600 m of overburden on the scoured platform, locally over widths of 300 km. Such deep erosion, accomplished in a very short time, is only possible if the eroded material was extremely friable. Overall, the observations and calculations show that problems remain with the hypothesis that the Kasei Valles were formed by gigantic, cataclysmic floods. In a companion abstract [14] it is shown that fewer problems exist and lesser discharges are required if the scour features were formed by ice rather than by floods.

References

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