On meanders and sinuosity of martian channels: R.A. De Hon, Pedernales Science Institute, Canyon Lake, TX 78133-5259

Introduction. Some martian valleys exhibit significant sinuosity. In fact, some channels have been described as meandering. The sinuous nature of martian channels has been cited as evidence of long-term persistent erosion by flowing water. Yet, very few martian channels exhibit meandering in the most common usage of the word.

The current use of the term "meander" is not unlike the early confusion in the use of the terms "valley" and "channel" (1, 2). Part of the problem arises from the various uses of the noun meander and the implications of the verb and gerund forms of the word. A meander is a large sinuous curve or bend in a stream. No implication about process is implied. On the other hand, the process by which a stream becomes a meandering stream implies a specific set of conditions. Namely, meandering requires a surface near base level, a stream in equilibrium (graded), and a prolonged period of lateral migration of a channel across a flood plain.

Terrestrial Meandering. Terrestrial streams meander when they are very near base level. Meanders have been demonstrated to be the result of balance between least work and maximum distribution of work (3). Meanders are highly probable shapes, provided the channel is adjusted (4). Unable to erode the floor of the channel, erosion take place at the channel wall. Sinuosity increases as curves migrate. Valley walls are widened and a valley flat is produced. Continued migration of meanders eventually produces a flat, wide, flood plain. The flood plain is characterized by a low relief surface with one or more meandering channels, meander belt, cutoff meanders, and avulsion channels.

Martian Sinuosity. Sinuous channel do occur on Mars, but sinuosity alone does not signal approach to base level, nor does it require prolonged flow Sinuous rilles carved by volcanic flows are common on the moon and Venus without base level control. A few abandoned sinuous channel loops can be found on Mars, but true meandering is scarce. Martian sinuous valleys are steep-sided with very little valley flat and no evidence of a flood plain. Terracing is rare, absent, or problematical. Cut off meanders are likewise rare and often are equivocal in their identification. Early references to meandering channels on Mars often cited incised, theater-headed valleys (5, 6) that are better described as sapping channels (7, 8) . The suspected meanders are "alcoves" cut by groundwater discharge at the base of a suitable aquifer .

Not all channels that exhibit lateral migration are meandering. Certainly some martian channels exhibit abandoned curves (such as Hrad Vallis and Nanedi Vallis). Such examples display minor adjustments of a consequent channel to removal of local minor blocking terrain or slumping of steep valley walls. As the outside of a curve is subject to maximum erosive force and possible undercutting, the channel may be diverted by slumping of the undercut embankment.

Flow Duration. Catastrophic outflow on Mars may last for days to several months (9, 10, 11). Once initial channels are established, episodic seasonal discharge may follow–but flow durations are limited. Outflow channels are extremely immature and follow consequent streams' courses. Sapping channels have a much longer lifetimes than outflow channels. Discharge may be episodic or continuous. The amount

of sediment removed during formation of the channels implies persistent, long term flow (12), but sapping channels on Mars appear to be void of well-developed or even rudimentary flood plains.

Short abandoned segments are found along the stream course of Nanedi Vallis and Hrad Vallis. Both channels are cut by–what would be in martian standards–long-term flow released from subsurface storage. Hrad Vallis appears to be a consequent channel cut by relatively long-term release from a fissure. Nanedi Vallis appears to be a valley cut by long-term headward erosion by groundwater sapping. Neither has developed an extensive flood plain; neither is a true meandering streams.

Local base levels are found where outflow channels debouch into craters. A true migrating meander loop is found in a delta near the crater Holden (13, 14). Most crater lakes have fairly short lifetimes as craters fill to overflowing during catastrophic flooding. Once filled, topping-flow cuts exit spillways that empty the crater impoundment. Deltas formed during filling of flooded craters are short-lived. Channel avulsions in delta regions on earth occur on short time-scales and are often accelerated during flood-stage.

Conclusion. Rare cutoff sinuous channel loops do not support prolonged flow necessary to establish equilibrium implied by a well-developed meandering stream. Abandoned channel-segments on Mars are an indication of minimum adjustment from an initial consequent flow. The best example of a true migrating meander loop is found on a delta where channel-course changes are common on short time-scales. A better measure of the persistence of flow-duration is in the volume of material removed from valleys by flow estimates limited by channel characteristics.

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