Dating of Gale Crater

1. The general consensus is that the Gale impact occurred ~3.5–3.8 Ga. This is a fairly significant timespan which could possibly be constrained by considering the probable evolution of gale in the context of other significant events. Figure 1 provides an admittedly broad brush depiction of the events that would have had a significant effect on Gale. The timescales have been drawn from numerous erudite papers however in the interests of brevity minimal papers are referenced.

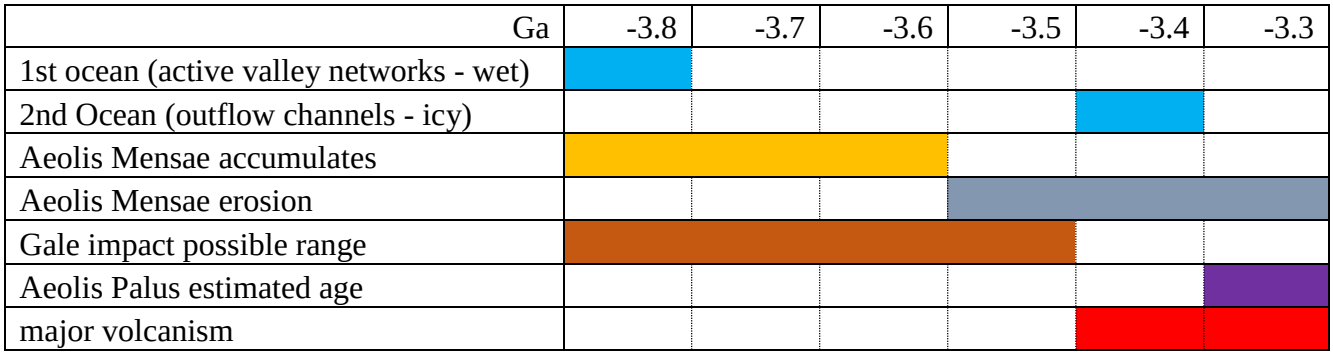

Figure 1. Approximate timelines of key phenomena affecting Gale

2. From the comparative timelines I suspect that that the Gale impact occurred early in the sequence and most likely around -3.8 Ga. This statement is not entirely wild speculation and is predicated on the following:

   a. The Northern rim is heavily eroded compared to the Southern rim. Potential reasons for this are:

      i. If the impact occurred after the Aeolis Mensae sediments had begun to accumulate against the dichotomy scarp then the northern crater rim could have incorporated a reasonable proportion of this sediment and would therefore be more susceptible to erosion than the southern rim, excavated from basement;

      ii. If a Northern Ocean did exist coincident with the active valley networks, which is a reasonable assumption, then significant groundwater could be expected to seep into the crater from the north, undermining and eroding the rim via tunnelling.

      iii. A northern ocean raises the possibility of erosion of the ejecta blanket and rim from occasional impact generated tsunami with occasional overflow into the crater.

   b. In support of abundant surface water post impact, Curiosity has confirmed fluvial and lacustrine deposition at the current erosional surface, while the exposures of phyllosilicate and hematite higher on Mount Sharp indicate that water influenced sediments extended hundreds of metres above the levels investigated by Curiosity. Grotzinger et al have estimate that sedimentary deposits extend some 1.5 km below the current surface of Aeolis Palus to the final crater floor. While residual impact heat would have generated reasonably long lasting hydrothermal influences the sediment volume far exceeds possible contributions from that source. Indications are that some

2 km depth of sediment deposition in the final crater was dominated by aqueous rather than aeolian processes.

3. Empirical evidence continues to accumulate, confirming that plentiful surface water existed on early Mars. How this is possible given the faint young sun hypothesis remains a mystery but then again the same mystery surrounds the presence of water on early Earth. With respect to a warmer, wetter Noachian Mars, empirical evidence trumps hypothetical modelling and indications are that surface water was present in abundance on two separate occasions. These relate to the active valley networks around -3.8 Ga, which would have required a large open water source and the catastrophic flooding of the outflow channels around -3.4 Ga. On both occasions water would have accumulation in the northern lowlands.

4. As the planet cooled surface aqueous activity ceased, with water apparently cold-trapped within subsurface aquifers [1], sealed by a thick permafrost / ice zone. During this period the continued growth of the Aeolis Mensae deposits [2] would have resulted in the crater being filled to at least the level of the central peak. While this depth of aeolian deposition is significant the remnants of the Aeolis Mensae deposits to the north and northwest of Gale indicate of this depth of sedimentation was widespread in this section of the dichotomy. This wide area deposition provides an explanation for the upper sediments of Mount Sharp which reflect aeolian dune fields.

5. Somewhere around -3.5 Ga deposition of Aeolis Mensae sediments gave way to erosion, resulting in the dissected sediment evident today. During this period Gale crater was exhumed to around the level of the current surface with the assessed age of Aeolis Palus [3] providing a yardstick for the cessation of meaningful erosion as atmospheric pressure dropped. Towards the end of this period the planets thermal activity surged, evidenced by the volcanism associated with the Tharsis bulge and Elysium. This surge in thermal activity initiated the catastrophic channel outflows, forming a second, icy northern ocean. It is likely that the late and limited fluvial events such as the Peace Vallis catchment and fan date from this period. This second ocean would have been smaller than the original will no capacity for tsunami related influences on Gale. [4]

6. While crystal balls tend to be unreliable when peering back 3 or 4 Gy indications are that the Gale impact occurred around -3.8 Ga.

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https://pdfs.semanticscholar.org/d762/d3319d28591c3f6dd3bcd187bad7c5dde58c.pdf

3. Grant, J.A. et al. The timing of alluvial activity at Gale crater, Mars. 45th Lunar and Planetary Science Conference (2014), http://www.hou.usra.edu/meetings/lpsc2014/pdf/1487.pdf

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