WHERE DID ALL TITAN’S CRATERS GO? C. A. Wood, Planetary Science Institute, 1700 E. Ft. Lowell, Tucson, AZ 85719. tychocrater@yahoo.com

How Many Craters?: After 12 years of Cassini’s radar mapping of Titan’s surface only a few dozen certain and likely craters have been identified [1, 2]. Because Saturn’s other satellites are heavily cratered, Titan originally probably was also; its surface must have been strongly modified to erase most craters. Explanations to account for their removal include burial by sediments, dunes, liquids, and deposition of hydrocarbon grains from the atmosphere. All of Titan’s known craters have been modified (by infill, fluvial erosion, and dune encroachment [1]), but there does not appear to be a smooth transition from relatively fresh to highly degraded craters. There is a rather abrupt transition from recognizable craters to very uncertain possible craters, perhaps ruins of some previous structures (ghost rings of [3]).

Surface Age: A major constraint relating to the removal of Titan’s craters is crater counts that imply an average surface age between 1 and 0.1 billion years [1, 2, 4]; the midpoint is about a half billion years. It is possible that all of Titan’s detectable craters date since that time, and that previous landscapes were not preserved.

Titan Evolution Model: A possible explanation for the removal of the first four billion years of Titan’s surface history is provided by the Tobie, Lunine and Sotin [5] model of the evolution of Titan’s atmosphere and crust (Fig. 1). In this model a very thin (about 10 km) clathrate crust rests on top of a deep water-ammonia ocean for the first 4 billion years of Titan’s history. About 0.6 billion years ago the crust quickly solidified to 50 km thickness.

Why the Craters are Gone: I propose that the surface of Titan is about a half billion years old because before that time the crust was too thin to preserve impact craters, volcanoes, mountains, and any other landforms that developed. Impacting projectiles smashed through the thin icy crust, releasing floods of water that destroyed forming craters. Similarly, any mountains that formed could not be supported by the thin crust. A half billion years ago the thickening crust started to retain impact craters and other surface features. Ghost rings [3] may be fragmentary remnants from the end of the thin crust era. This interpretation is similar to Cloud’s [6] tempestuous tectonics model for the Hadean Earth, where little record remains of vigorous volcanism and intense impact cratering because of an early thin crust.

The earlier ten kilometer thick crust would presumably have been frequently resurfaced as impact cratering and faulting associated with the movement of the crust allowed eruptions of massive floods of liquids that froze at the surface. Recorded time (as measured by the accumulation of impact craters) began on Titan only after the crust thickened and inundations stopped, about a half billion years ago.

Like Europa, early Titan would have been an icy sphere cut by numerous crevasses and fractures. The repeated spread of ocean lavas across the surface would have released great amounts of methane with fallout of carbon-rich grains derived from organic photolysis products [7]. These layers would have been covered by subsequent floods of eruptive lavas, and hence dunes and other possible atmospheric deposits detected today have not been accumulating on Titan’s surface for 4.5 billion years.

A consequence of this speculative history is that many of the process rates determined for fluvial erosion, atmospheric sedimentation, etc., which assume 4.5 billion years of action, would have been much higher, if everything visible on the surface is less than 0.5 billion years old.

References:

Fig. 1: Methane release (top), and crustal thickness (bottom) over time, according to [5].