Rewriting the Landform History of One of Africa's Three Largest Basins

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Main Perspective
The Kalahari Basin in southern Africa – one of the largest basins in Africa, along with the Congo and Chad basins – has attracted attention since David Livingstone traveled through the area in the 1840s. It is a semiarid desert with a large freshwater swampland known as the Okavango Swamp (150 km radius). This prominent megafan (a fan with radii >100 km), with its fingers of dark green forests projecting into the dun colors of the dunes of the Kalahari semi-desert, has been well photographed by astronauts over the years (figure 1). The study area in the northern Kalahari basin is centered on the Okavango megafan of northwest Botswana, whose swampland has become well known as an African wildlife preserve of importance to biology and tourism alike.

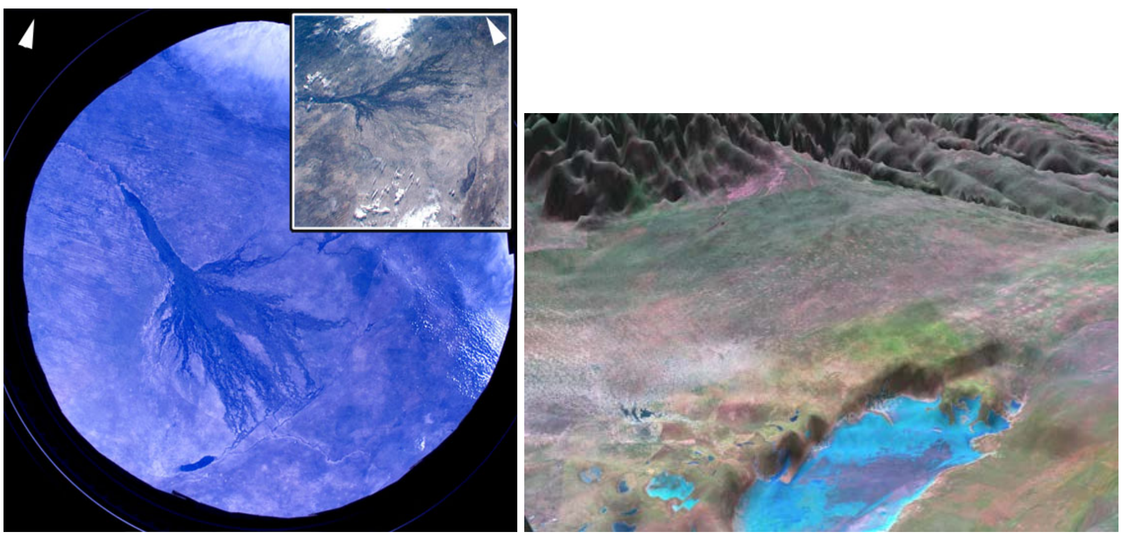

Figure 1.– Northern Kalahari Desert megafans.
(Left) Fingers of riverine forest of the Okavango megafan mark the distributaries of one of the prime megafan examples on Earth.
(Right) Vertically exaggerated Shuttle Radar Topography Mission (SRTM)-based oblique view of the Cubango megafan, the largest fan in the study area (310 km radius), with Etosha dry lake depression in the foreground.

The Okavango River is unusual because it has deposited not one but two megafans along its course: the Okavango megafan and the Cubango megafan (figure 1). The Okavango megafan is one of only three well-known megafans in Africa. Megafans on Earth were once thought to be rare, but recent research has documented 68 in Africa alone. Eleven megafans, plus three more candidates, have been documented in the area immediately surrounding the Okavango feature. These 11 megafans occupy the flattest and smoothest terrains adjacent to the neighboring upland and stand out as the darkest areas in the roughness map of the area (figure 2). Megafan terrains occupy at least 200,000 km^2 of the study area.

The roughness map shown in figure 2 is based on an algorithm used first on Mars to quantify topographic roughness. Research of Earth's flattest terrains is just beginning with the aid of such maps, and it appears that these terrains are analogous to the flattest regions of Mars.

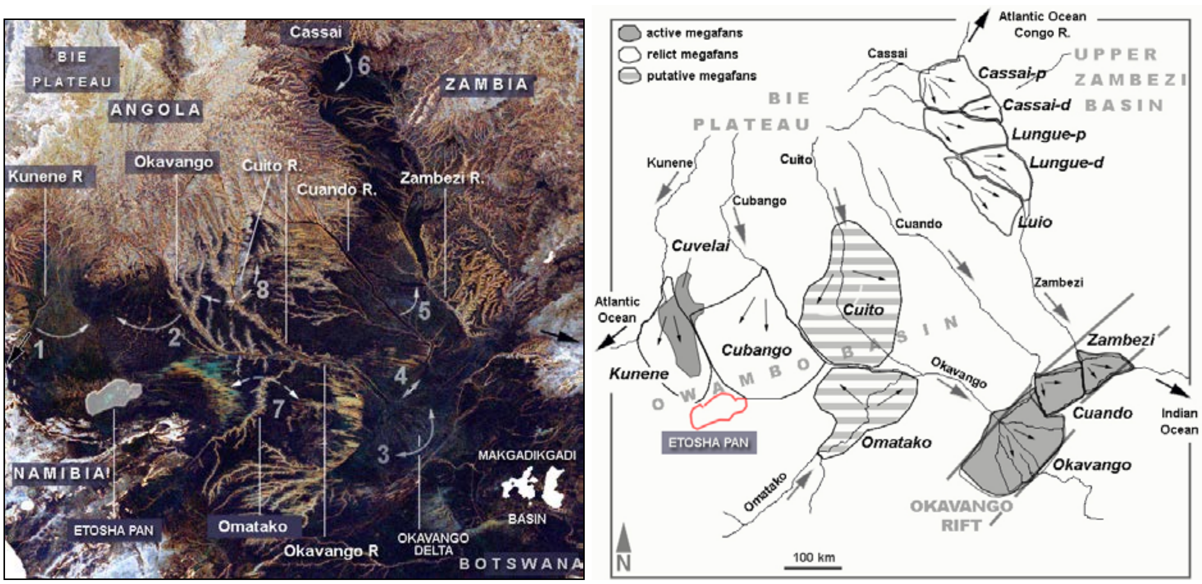

Figure 2.– Megafans as the flattest and smoothest terrains. Mars roughness map algorithms were used to construct this Kalahari Basin roughness map.
(Left) Most of the darkest zones represent large fluvial fans. Numbers refer to those fans where normal river avulsion directs discharge of major rivers into separate subbasins. Arrows indicate channel sweep on each megafan. Brighter tones are eroded uplands and dunefields with longer baseline roughness (see Wilkinson et al., 2006).
(Right) Megafan types (named after formative rivers). Differences in megafan type in each subbasin are striking: active in the rift, relict in the other basins, and two putative megafans. This sample probably points to likely megafan variability in African basins generally.

Implications

1. The variability in depositional style in each subbasin may apply Africa-wide: rift megafan length is dominated by rift width, whereas Owambo subbasin megafans are probably controlled by upland basin size (figure 2); Zambezi subbasin megafans appear more like foreland basin types, with the position of the trunk river controlling size.
2. These perspectives were successfully applied to identify the largest megafan in the group (Cubango, figures 1 and 2), a fan that was sufficiently overprinted by dunes and dry lakelets not to be detectable remotely. Such undertsanding can probably be applied on Mars, where Earth experience suggests megafans ought to exist.

3. Sweep angles of rivers on megafans drastically change the hydrology in some subbasins (figure 3): when the Cubango and Kunene rivers were oriented to the Etosha Pan, it was probably a permanent water body. Now that the rivers are oriented away from the basin, 93 percent of the discharge area from the pan's northerly (main) source area is gone.

4. Biotic contact between major river systems was probably controlled *by megafans situated on divides*: various fish species that originated in the Congo basin are now found in the Upper Zambezi R., and *vice versa*, apparently because of river switching behavior on the Cassai megafan (6, figure 3) that has mediated migrations both to the south and the north.

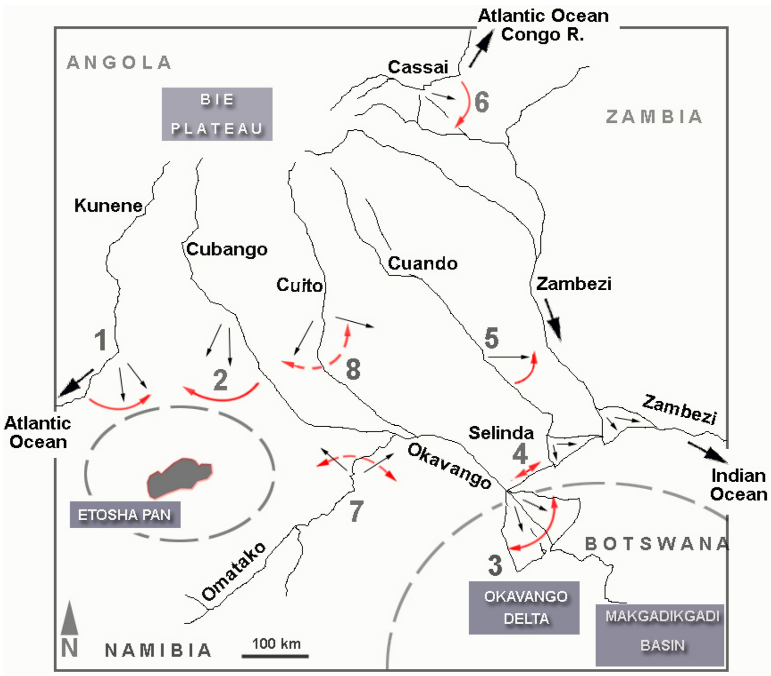

Figure 3.– Arrows indicate channel "sweep-angles" on megafans located astride basin divides. This unappreciated characteristic of megafan location appears to explain many interbasin aquatic species' distributions (Wilkinson et al., in prep.).