VOLATILES IN THE DESERT: SUBTLE REMOTE-SENSING SIGNATURES OF THE DAKHLEH OASIS CATASTROPHIC EVENT, WESTERN DESERT, EGYPT

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Introduction:

Over the past decade members of the Dakhleh Oasis Project have studied enigmatic signatures in the Pleistocene geologic record of portions of the Dakhleh oasis and palaeo-oasis in Egypt's Western Desert [*Kleindienst et al.*, in press; *Mills*, 2000]. In particular, Ca-Al-Si rich glass melt (Dakhleh Glass, DG) points to a catastrophic event between c.100,000-200,000 years ago [*Schwarcz et al*, in press] in this well-studied African savannah and freshwater lake Mid-Late Pleistocene environment [*Churcher et al.*, 1999; *Kleindienst et al.*, 2004].

Geologic Setting:

The Oasis of Dakhleh is located in the center of Egypt, in the Egyptian Western Desert between latitudes 25°10' and 25°55' N and longitudes 28°30' and 29°35' E. The Dakhleh region's bedrock geology consists of a Late Cretaceous layer cake. sediments dipping northward at 1° to 3°, and with shallow east- to west-trending, sinusoidal anticlinal-synclinal waves. The Maghrabi Fm. and the overlying Taref Fm. sandstones of the Nubia Group (Grp.) form the local base, and reach surface some distance south of the oasis rim in the Dharb el–Arba'in Desert plain. Overlying the sandstones and forming the cultivated oasis floor is the Mut Fm. [Quseir Grp. = Variegated Shales], of Tethyean littoral red muds and greyblack shales, sometimes incorporating a more clastic and fossiliferous member. Above the Mut Fm. lies the Duwi Fm. (= Phosphorites), near-shore phosphoritic limestones and shales, of which the more consolidated phosphate-rich layers cap the Piedmont below the Libyan Escarpment, and provide control points for Pleistocene P-III gravel terraces. The main rise of the Libyan Escarpment is in the 200 m thick, black marine shales of the Dakhla Fm. The Escarpment bounding the oasis on the north and east is capped by the 50 m thick Tarawan Grp. chalky limestones, whose resistance supplies the Plateau rim.

Two palaeobasins are defined by Pleistocene lacustrine sediments: 'Kellis Palaeobasin' in the west, and the 'Teneida Palaeobasin' south and east of the modern oasis. Faunal and vegetal remains allow an environmental reconstruction indicating reedy lake-margins, savanna-grassland with scattered trees, some forest, perhaps even on the Libyan Escarpment. An indurated, meter-thick calcrete layer typically caps the calcareous lake sediments. The basin centers host the lacustrine 'Calcareous Silty Sediments' (CSS) deposits which originally covered the basins and now stand as butte-like remnants. Figure 1 maps the palaeobasins.

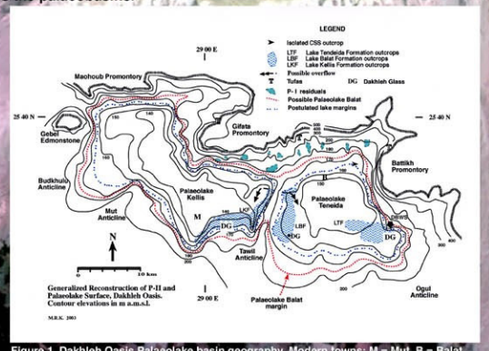

Figure 1. Dakhleh Oasis Palaeolake basin geography. Modern towns: M = Mut, B = Balat.

The area southeast of Teneida and below the narrow Piedmont zone south of Battikh Promontory has been mapped as Mut Fm. overlying Taref Fm. The conformable Mut Fm. sequence here differs from that most often exposed further west in Dakhleh: the red mudstones are overlain by light-coloured sandy and limey shales, and then by a thin, friable sandstone horizon with a blocky fracture. This sequence is best exposed in Snake Hill to the west of the DBWS, and at the Mut Pillar on the northern edge of the area of disturbed bedrocks. The sequence can be traced north to near the foot of the Escarpment where mudstones or variegated shales again appear. The Mut/Duwi formational contact is missing further south. However, the area north of the rims of Camel Thorn Basin and western el-Akoulah Pan is either a depression or a down-faulted area of bedrock in which Duwi Fm. shales interbedded with more consolidated limey horizons overlie the Mut contact. Veined green shales (Duwi Fm.?) apparently overlie typical Duwi beds (below). This is the area that was impacted by a meteorite strike or strikes, which altered sediments and severely disturbed the bedrock sequence.

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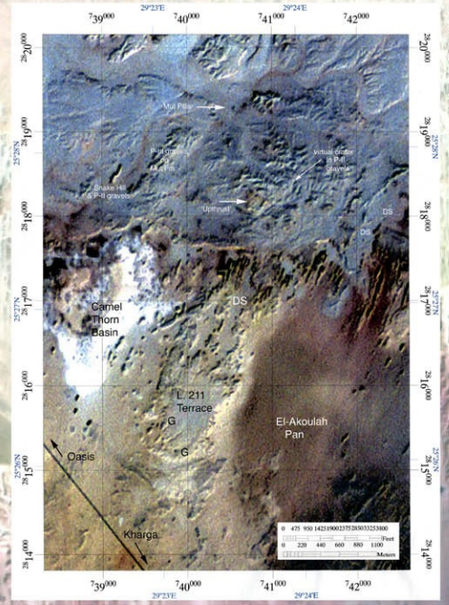


Figure 2. Landsat ETM+ map of the DBWS and adjacent Holocene Camel Thorn Basin and El-Akoulah Pan with Location 211 site of Dakhleh Glass (G). Red, green and blue are assigned to bands 3, 2, and 1 respectively, which appears to highlight the limestone gravel-covered surfaces in blue, distinguishing them from the Teneida Palaeobasin CSS areas with yellowish colors. The Camel Thorn Basin is white due to gypsum, and the El-Akoulah Pan's brown is due to included Mut Fm. clay plates. The DBWS comprises the 'Upthrust' and the circular 'virtual crater' in P-II gravels. DS indicates sites with displaced bedrock sediments, characterized by inversion relationships. UTM Zone 35N; Datum: WGS-84

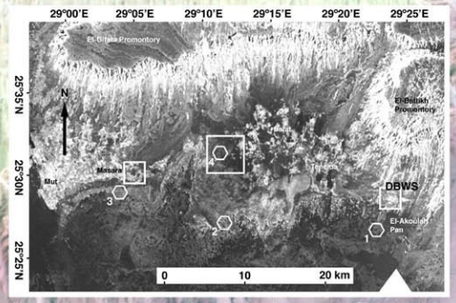


Figure 3. Composite 5-cm (C-band) wavelength radar image of the Dakhleh Oasis Region is made from Shuttle Imaging Radar (SIR-C) processing runs 16113 (left) and 16095 (right). The oasis area encompasses the towns of Mut, Masara, Balat, and Teneida. Shown are the areas of Dakhleh Glass at (1) Location 211, (2) Loc. 390, (3) Locs. 397-398, and at (4) Sarcophagus Hill. The Dakhleh Bow Wave Structure (DBWS) southeast of the oasis is comprises the brightest radar area in level terrain that is not vegetated, and is, so far our best candidate site for an impact structure. The additional proposed circular features, or 'virtual craters', in the unlabeled boxes located within the oasis proper, and lying north-east and north respectively of the Dakhleh Glass occurrences at (2) Loc. 390, and (3) Locs. 397-398, are visible only on the radar imaging. We have previously suggested that these features may result from meteorite impacts or airbursts, and account for the formation of the glass at these other locations, though the discovery of DG at (4) during the 2005 field season has confused the story.

Glass Gallery:

Figure 4. Small patch of lagged DG at Loc. 211 CSS terrace near the southwest edge (see Figure 2). Sample was excavated from the degraded silts that cap the lakebeds. The DG clasts were found on and within upper part of silts, in a typical lag deposit on fine sediments of Dakhleh.

Figure 5. Loc. 211 CSS terrace, south edge, with Dakhleh Glass pieces spilling down the talus face. CSS rests on Taref Fm. sandstone. Small DG clasts ('blobs') here appear to be intact, with larger pieces also associated.

Figure 6. Dakhleh Glass fragments at Loc. 390, Occurence 2, lagged on CSS facies of Lake Balat Fm. at time of discovery. Surface of the CSS is calcreted and glass seems to incorporate some of the underlying sediment. Glass about 10 cm thick.

Figure 7. A typical piece of Dakhleh Glass from Loc. 397. Fragment is 4 cm across.

Figure 8. A 30 cm Dakhleh Glass Fragment from Loc. 398 showing cm-sized gas-vesicles erupting on the surface.

The Enigmatic Evidence of Catastrophe:

The vesicular Dakhleh Glass melted at 1100°C to1200°C, near the eutectic for its composition– barely melted? The glass is not a human-produced slag: there are no signs of human activity associated with the DG, while Paleolithic sites are found throughout the oasis. The Ar-Ar dating argues against any recent production.

The Dakhleh Bow Wave Structure is so far the only structurally compelling site that might be explained by an impact, yet the tilted Duwi Fm. beds dip too steeply for a standard crater model. Also, the DBWS upthrust itself is elongated, and is south of the more circular topographic features that are highlighted by radar (Figure 3), Landsat (Figure 2), and by airphotos (Figure 11). If this structure is impact-produced, its size is likely 300-800 m.

The DG is spread over 30 km, which is hard to explain for standard ejecta from a 100's m crater.

The DG occurences found to date correlate well with the paleolake basins (Figure 1).

DG composition is a good match for local target rocks (requires confirmation).

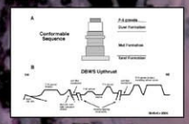
DG thin sections from Loc. 397 contain calcite spheres and globules, not unlike those found in impactites at the Haughton impact structure, Canada (e.g., *Osinski and Spray* [2001]).

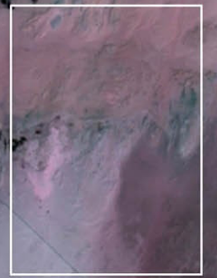
Is DG an example of a deposit of *Schultz and Mustard*'s [2004] "high-speed, molten ejecta decoupled from later stages of crater excavation" ?

The remote sensing signatures of the catastrophic event are subtle at best: field work will be key. We are planning a taphonomic survey of the DG sites, a survey of the 'virtual craters', and a detailed mapping of the DBWS.

Figure 9. West to east composite view of the Dakhleh Bow Wave Structure 'up-thrust' feature, as seen from the P-III limestone gravel-capped ridge to the south. Note circular aspect within the veined green shales inside the upthrust (black arrow), which is picked-out by morning light, suggesting that the feature is an eroded impact crater (photo: Kleindienst. Feb., 2004, 11:00 a.m., yellow filter).

Figure 10. Stratigraphy and profile through the DBWS upthrust, defined by steeply tilting Duwi Fm. beds.





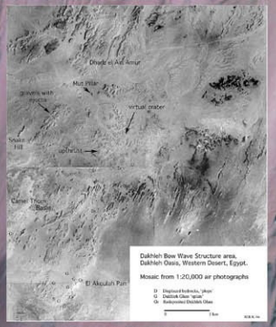


Figure 11. Airphoto mosaic of DBWS. The coverage is approximately the same as with Landsat in Fig. 2, which is outlined on the background image (ASTER short-wave infra-red bands 497 RGB, Mar. 30, 2002) immediately to the left.

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