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IMPACT OF THE PARAMETERS OF A MORPHOLOGICAL AND MORPHOMETRIC OF MEGA-OBSTACLE ON THE FIELD SHELTER

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ABSTRACT:
The morphometric parameters of topographic barriers have an influence on the formation of the shelter area in the wake downwind of the obstacle. This is based on Meteosat images where the wind flow around the rock formations of the Sahara and Sahel is clearly visible. To support this assertion, correlations between the area of shelter and the following parameters: area, shape, elongation, flattening, faces the wind and the front of the obstacle to the wind was conducted topographic. It appears that the altitude of the massif has no significant effect on the area of shelter.

Keywords: *Sahara-Sahel, topographic obstacle, wind circulation, morphometric parameters, shelter area, Meteosat satellite images*.

Abbreviations: Cf: shape factor, L = length of major axis of the area (km) S0 surface of the base of the obstacle (km2) e: front wind (km) h: average height of obstacle (m), A: area of the massif (km ²), B ': surface wind (km ²), B: panel area shelter (km ²) Dn: nominal diameter (km) AP: coefficient flattening.

1. INTRODUCTION

The wake-called recirculation area yet, or shelter area is an area that appears to down-wind of the obstacle, it is the seat of fast movements, disordered and disturbed fluid where speeds, very variable in time direction and magnitude, are zero on average. The boundaries of the area of the wake are essentially fluctuating and poorly defined which induces a large amount of exchange of matter and energy. The wake caused by the flow around bridge piers in a river is responsible for scour that occur downstream of these batteries (*Purple PL et al, 1998; Lencastre A., 1984*), which reach depths of scour concern and have implications for the stability of the structure. In érémologie, we see that it is in the area downwind of the reliefs that are manifested most powerful wind phenomena.

The area downwind is marked by wind shear, which for the most turbulent areas, spread to the down-wind of the barrier several kilometers, as a wake instability. In arid regions, the wind flow carrier sand barriers around the mega-producing areas of accelerating flows of considerable size which can have dangerous consequences on human activity (roads, houses, airports...).

These sudden accelerations of wind between two mountain ranges are partly responsible for the self-maintenance System Global (GWAS), which relates the Sahara and the Sahel. We addressed in this study changes in the area of shelter based on characteristic parameters of a mega-obstacle.

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2. DATA AND METHODS

2. 1. Definition of morphological parameters

The characteristic parameters of a mega-obstacle are:

- Form factor (Cf)
- Characteristic coefficient of the sandy deposit upstream of the obstacle (R)
- Nominal diameter (Dn)
- Coefficient of flattening an obstacle (AP)
- Elongation Modulus (η)
- Degree of asymmetry of the obstacle (Is)

2.1.1 Shape factor of the surface of a mega - obstacle (CF)

The area of an obstacle influences the deposition of ergs (formed in the vicinity of the barrier) and the area downstream wind shelter. We define the shape factor of the surface of the base of an obstacle (Cf) as the ratio between the surface of the base (S_0) of the obstacle and the surface of (π $L^2/4$) (**Fig. 1**).

$$\mathbf{C_f} = \frac{\mathbf{S_0}}{\frac{\pi\,\mathbf{L^2}}{\mathbf{4}}}.$$

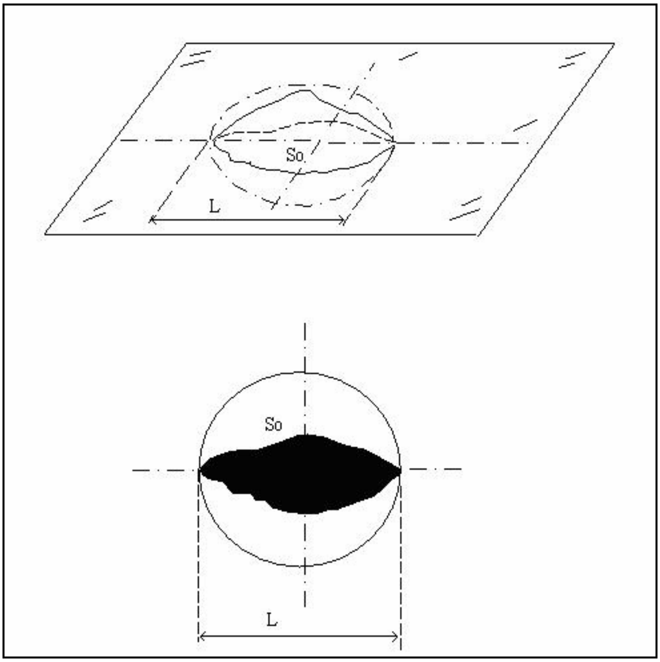


Fig. 1 Diagram of obstacle

2.1.2 Coefficient of sand deposition on the upstream of the obstacle-wind (R) (*Remini, 2001*)

To characterize the volume of the accumulation of sand at the upstream of a mega -obstacle has been defined a relationship between the front wind (e) and the maximum length of the massive (L) depending on wind direction, the sandy deposit ratio (R).

$$\mathbf{R} = \frac{\mathbf{e}}{\mathbf{L}} \qquad (0 < \mathbf{R} < 1)$$

If e/L tends to 1, the sand deposit is considerably upstream of the obstacle
If e/L tends to 0, the sand deposit is low at the upstream of the obstacle
Three main cases may occur:

First case: (R tends to 1 and Cf toward 0)

The contour shape of the massif is angular and non-geometric, the shape factor (Cf) tends to 0. The front wind (e) is maximum, it represents the greatest length of the base of the massif (L), i.e. the deposition coefficient (R) tends to 1 (**Fig. 2**).

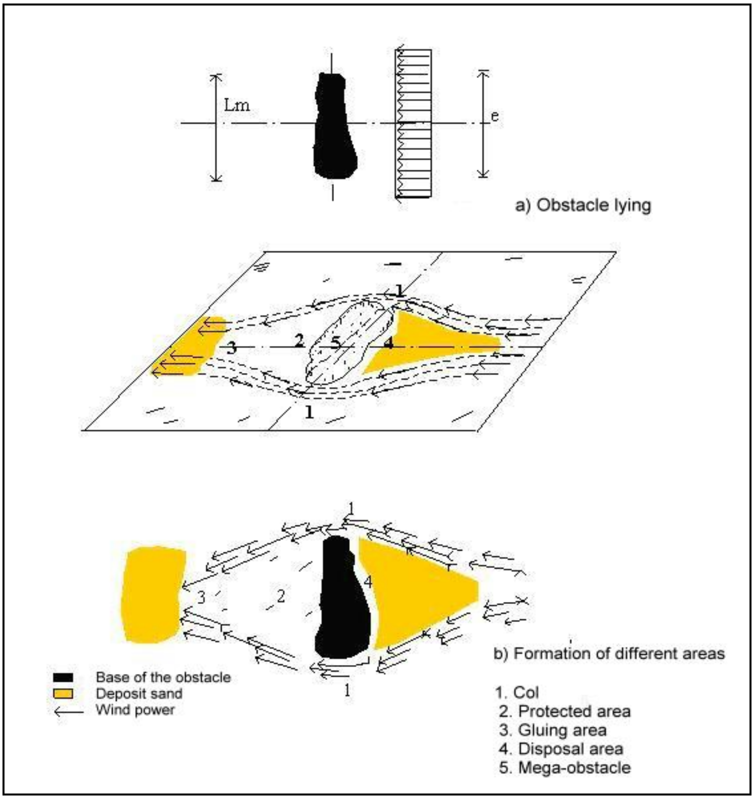


Fig. 2 Diagram of the different areas tends to 1 when R tends to 0 and Cf

When the wind is perpendicular to the largest side of the barrier occur:

- a considerable loss caused by the ends of the base surface of the obstacle,
- a large deposit of sand upstream of the obstacle,
- a large area of shelter in the form of a triangle,
- a long length of reattachment (L’).

Second case: (R tends to 1 and Cf toward 1)

The shape of the surface of the base of the obstacle of the massif is rounded, the shape factor (Cf) approaches 1. Mostly for this circular base case, whatever the wind direction, wind forehead (e) is almost equal to the maximum length of the base of the massif (L), the deposition coefficient (R) tends to 1, the wind is perpendicular to the greater length of the base of the massif (L) (**Fig. 3**). In this case, will occur:

- low pressure drop due to the rounded shape of the massif;
- two major areas "neck" of both sides of the massif, characterized by acceleration in wind speed and a decrease in air pressure;
- a sandy deposit more or less large upstream of the massif;
- a small shelter area downstream of the mass;
- low reattachment length (L ').

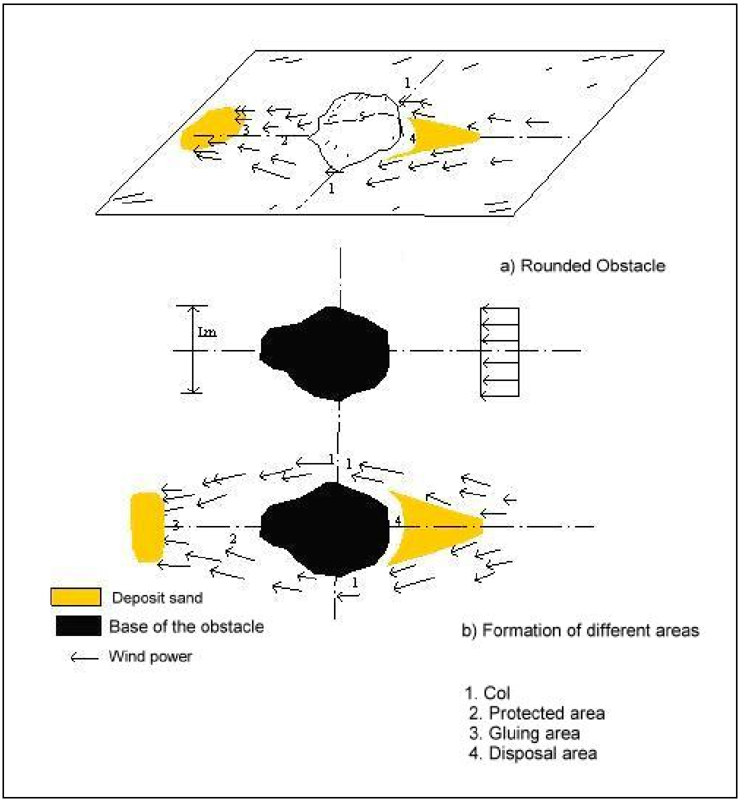


Fig. 3 Schematic of the different areas tends to 1 when R tends to 1 and Cf

Third case: (A and C goes to 0 tends to 0)

The shape of the base of the massif is angular and distorted, the shape factor (Cf) tend to 0. The front wind (e) is low, the deposition coefficient (R) tends to 0, ie the wind is parallel to the longest length of the base of the massif (L) (**Fig. 4**). In this case, occur:

- low pressure drop, since the wind is small;
- low sandy deposit upstream of the solid;
- a small area of shelter,
- areas of "neck" wider and more elongated.

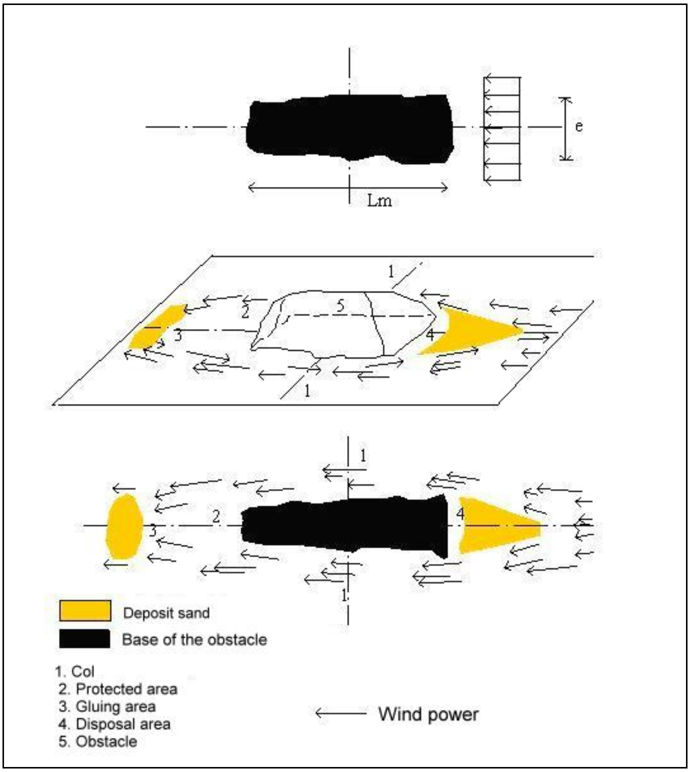


Fig. 4 Diagram of different areas when R goes to 0 tends to 0 and Cf

2.1.3 Nominal diameter (DN) of the base of a rock mass

The nominal diameter of an obstacle is the diameter of the circle in which the base is part of the massif. Let the surface of a circle of diameter Dn:

$$S_O = \frac{\pi D_n^2}{4} \text{, or to } D_n = (4\,S/\,\pi)^{1/2} \quad \text{with } C = 4\,S/(\,\pi\,L^2)$$

Or to $\mathbf{D_n = L \times (\,C_f\,)^{1/2}}$

The extension of the surface of the obstacle slows the wind speed and consequently increases the deposition of sand, the shape factor of the surface remains low (*Remini, Mainguet, 2004*).

2.1.4. Kurtosis of an obstacle (AP)

The flattening of a rock mass is a parameter determining the shape and size of the shelter area that forms the down-wind of the obstacle and especially the accumulation of sand on the upstream wind. Based on this idea, we defined the flattening of mega-barrier by the coefficient (*Remini, Mainguet, 2004*):

$$Ap = \frac{l}{h}$$

$$0 < Ap < \infty$$

Where:
1: is the maximum deviation between two parallel tangents which are perpendicular to both tangents that have shaped (L) the width of the base of the massif (km) (**Fig. 5**).
h: height of the mass (m).

- If Ap goes to 0, the solid is angular.
- If Ap goes to infinity, the mass is flattened.

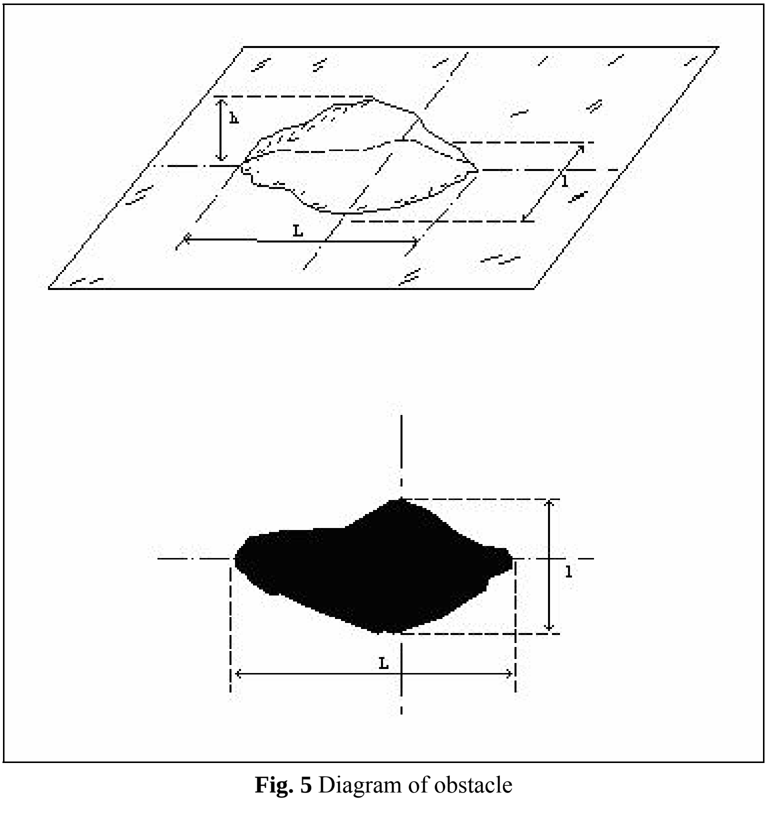


Fig. 5 Diagram of obstacle

2.1.5 Elongation coefficient (η)

We defined the elongation (η) of an obstacle by the ratio between the longest and largest width of the base of the massif (*Remini, Mainguet, 2004*).

The lengthening of the base of a rock mass is a determining factor that greatly affects the shape and size of the erg formed upstream of the massive wind-and also on the panel area shelter that forms at the downstream wind mass.

$$\eta = \frac{L}{l}$$

$$0 < \eta < \infty$$

- tends to 0, the solid has a rounded shape.ηIf the coefficient
- the solid form has a very elongated along a η ∞, if the coefficient tends to line perpendicular to the wind.

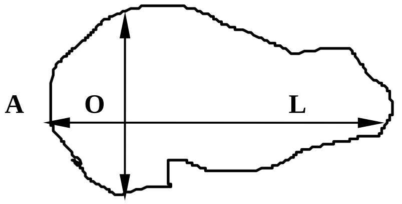
2.1.6 Coefficient of asymmetry of the obstacle (I_S)

The symmetry of a rock mass subjected to wind transport of sand is a crucial parameter (especially when the head wind is the greatest length of the base of the mountain) which has an influence on:

- subdivision of the flow into two roughly equal parts;
- the formation of dunes shaped "Sif" in the area of reattachment, induced by the encounter of two equal branches of wind;
- areas of "neck" which have almost the same shape and the same surface;
- the area of shelter that takes a form more or less triangular.

In case the solid has a large asymmetry has its base, there is an imbalance between the two branches of wind formed on both sides of the obstacle, the point of reattachment is pushed to the part where the wind speed is less strong. For the dunes that are formed in the reattachment area, there will be little "Sif" but preferably barkhaniques dunes.

The asymmetry of the obstacle is characterized by the coefficient.



$$I_S = \frac{AO}{L}$$

$$\frac{1}{2} \leq I_S \leq 1$$

- When the coefficient of asymmetry (Is) tends to 1, form the base of the mountain is rather asymmetrical (**Fig. 6**).
- When it approaches 1 / 2, the area of the massif is rather symmetric (**Fig. 7**).

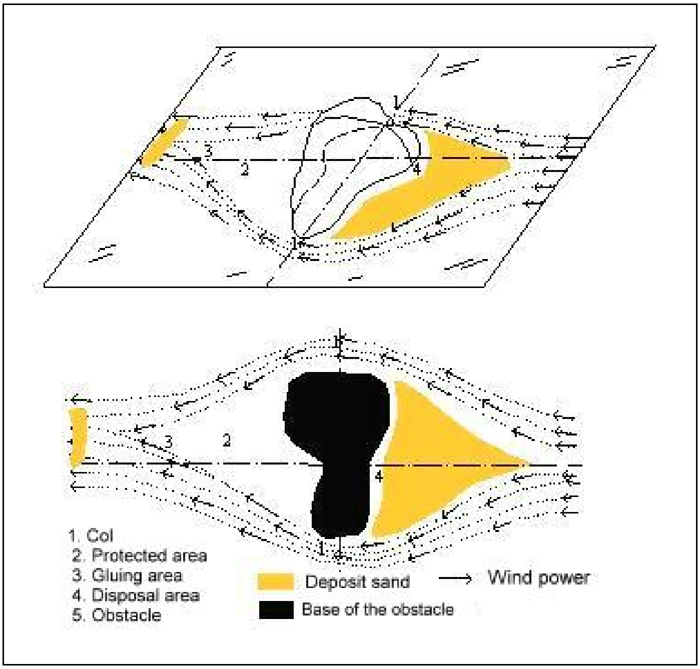


Fig. 6 Distribution of areas: the case of a mega-barrier asymmetric

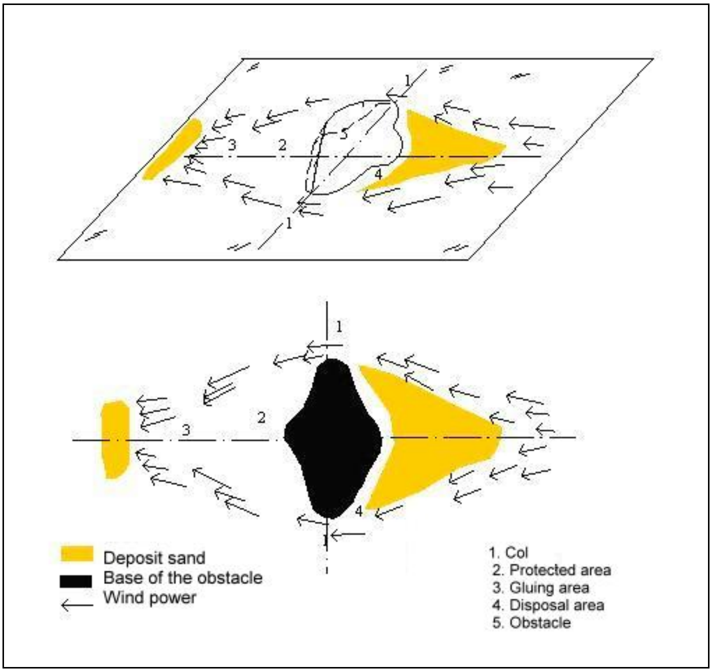


Fig. 7 Distribution of areas - Case of a mega-symmetrical barrier

2.2. Mega-obstacles are studying

Based on satellite imagery and geometric data of rock masses from the Sahara and Sahel, we have assessed the morphological parameters of the mega-barriers (**Fig. 8**).

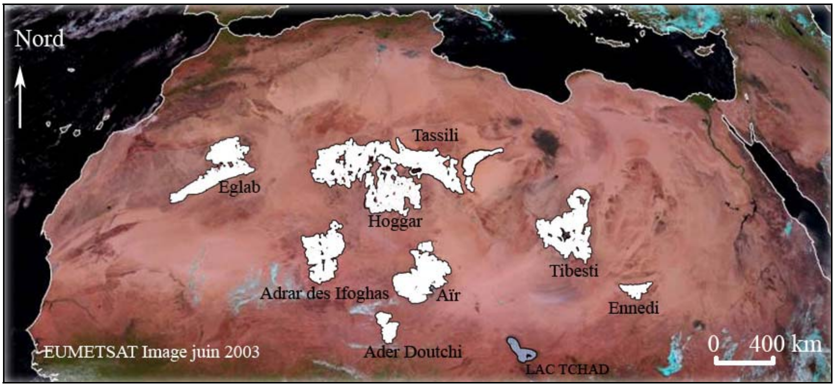


Fig. 8 Distribution of mega-barriers (Eglab, Tassili Hoggar, Adrar des Ifoghas, Tibesti, Air, Ader Doutchi, Ennedi and Lake Chad) in the Sahara and its margins

3. RESULTS AND DISCUSSION

3.1 Applications of morphometric parameters for mega-challenges of the sahara-sahel

3.1.1 Shape factor

In **Table 1** are shown the values of "Cf " (shape factor) and "R" (coefficient of deposit) for mega-hurdles: Hoggar, Tibesti, Eglab, Koutous, Jebel Archenu, Adrar Madet, Ennedi (*Remini, Mainguet, 2004*).

Table 1. ***Values of "Cf " and "R"***

Massive	« C_f »	« R »
Hoggar	0,07	0,5
Tibesti	0,44	0,61
Eglab	0,64	1
Koutous	0,78	0,91
Djebel Archou	0,22	0,41
Adrar Madet	0,16	0,93
Ennedi	0,57	-

It is interesting to note that the massive Koutous approaches the circular form (Cf = 0.78), followed Eglab (Cf = 0.64). The front of the wind barrier of Eglab is the largest base length (R = 1), which results in high deposition of sand on the upstream wind-solid forming Erraoui Erg. It appears that over the forehead in the wind, the greater the area of shelter and increased wind speeds at high collar and become strong wind erosion.

Over the shape of the solid surface is irregular (Cf. toward 0), the more it tends to slow the wind and build a huge loss and subsequently, promote the sandy deposit at the upstream of the massive wind. The area of sandy deposits in the wind upstream of the barrier depends on the wind direction that is upwind of the front, or simply the index of the sandy deposit (R). By cons, if the shape of the surface of the base of the massive circular (Cf. toward 1) the filing with the wind upstream of the obstacle is less.

3.1.2 Kurtosis

If the kurtosis (Ap) is great, the mountain is flat, the face of the obstacle to wind is small, the deflection of wind transport of sand on top of the range is large, the area of shelter formed downstream wind and sand accumulated in the upstream wind of the obstacle are small area. By cons, in case the coefficient Ap is low, the opposite is true. **Table 2** shows the values of kurtosis of some topographic obstacles in the Sahara and Sahel (*Remini, 2001*).

Table 2. ***Kurtosis of massive***

Name of the obstacle	Value of the coefficient A_p
Djbel Archenu	26,6
Adrar Madet	6,15
Koutous	50
Tibesti	250
Ennedi	95
Eglab	500
Hoggar-Tassili	217
Air	180

It is interesting to note that for the small massif of Adrar Madet, the kurtosis is lower, equal to 6.15, which means that this barrier is sharp and high. By the massive Eglab cons, with a kurtosis equal to 500, more valuable than the other mountain, represents a barrier down and flat. The vertical component of wind speed, in addition to the two subdivisions of the current on both sides of the solid occurs more at Eglab for Adrar Madet; shelter area is much larger in the wind downstream of the obstacle and downstream of Eglab wind Adrar Madet.

3.1.3 Coefficient of elongation

To compare the coefficients of the massive extension in the Sahara and the Sahel, we have shown in **Table 3**, the modulus values of elongation of these obstacles (*Remini, 2001*).

Table 3. ***Modulus values of elongation***

Name of the obstacle	Value of modulus η
Djbel Archenou	1,45
Adrar Madet	5,50
Koutous	1,90
Tibesti	1,10
Ennedi	1,20
Eglab	3,00
Hoggar-Tassili	3,00
Air	1,50

We note that the Adrar massif Madet is more elongated (η = 5.50), while the bulk of the Tibesti and Ennedi are rather less (η = 1.10 and 1.20) and, more precisely, that 'they have an area in the shape of an equilateral triangle. The shelter area formed at the downstream wind Adrar Madet is relatively larger than that formed by the Tibesti and Ennedi.

3.1.4 Coefficient of skewness

To compare the asymmetry of a few clumps around the Sahara and the Sahel, we have shown in Table 4, the coefficient of skewness of these obstacles.

Table 4. ***Values of the Asymmetry index***

Name of the obstacle	Asymmetry index (I_S)
Djbel Archenou	0,51
Adrar Madet	0,57
Koutous	0,74
Tibesti	0,55
Ennedi	0,90
Eglab	0,80
Hoggar-Tassili	0,66
Adrar Ifoghas	0,68
Air	0,71

It is interesting to note that the massive Djbel Archenou, Adrar Madet Tibesti and have a symmetrical shape and, cons, obstacles and Ennedi Eglab rather have an asymmetrical shape, elongated in the wind.

3.2. Relationships between morphological parameters and the area of shelter

3.2.1 Effect of the size of the obstacle (A)

The first geometric parameter that influences the shelter area is the area of the obstacle. The **Fig. 9** shows a correlation between the size inversely proportional barriers and shelter area. However, this correlation was not constant and shows that the parameter size is not significant in itself. We have shown in **Fig. 2** the area of shelter (B) depending on the size of the obstacle (A). It is interesting to note that there is a clear correlation of power between the two shape parameters

We therefore confirm that the area of mass strongly influences the size of the protected area formed at the down-wind of the obstacle and on the extent and distance downwind of the obstacle point encounter wind currents from both sides of the massif. This data determines the formation of an erg (drop zone) to positive sediment budget and especially the remote-deposit more or less far-downstream wind mass.

3.2.2 Effect of head wind (e)

According Mainguet M. et al. (1983), setting the front to the wind (e) may affect the area of shelter. Based on this idea, we tried to see the influence of this parameter on the panel area shelter (B) formed by the obstacle. **Fig. 10** shows the square footage of the front cover according to the wind. There is good correlation of the exponential form between the two parameters:

$$\mathbf{B=25\ e^{1,35}}$$

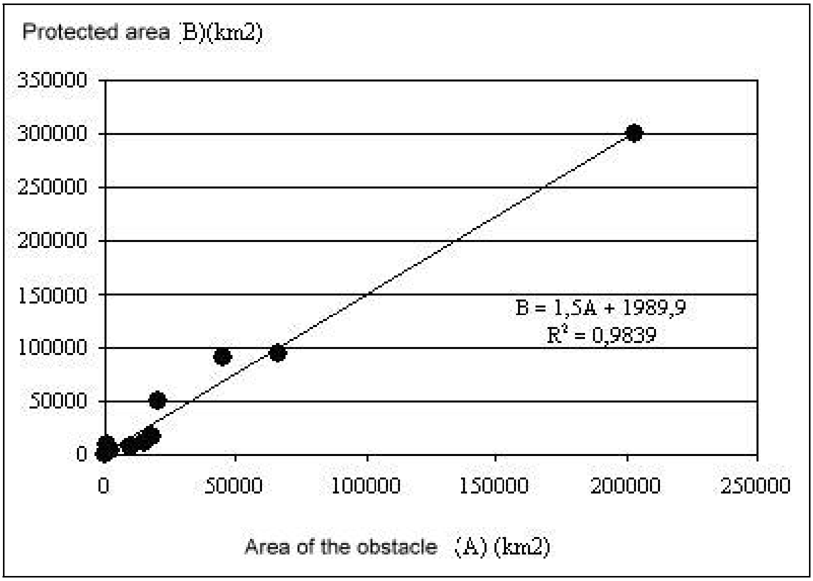


Fig. 9 Relationship between protected area and the size of the obstacle

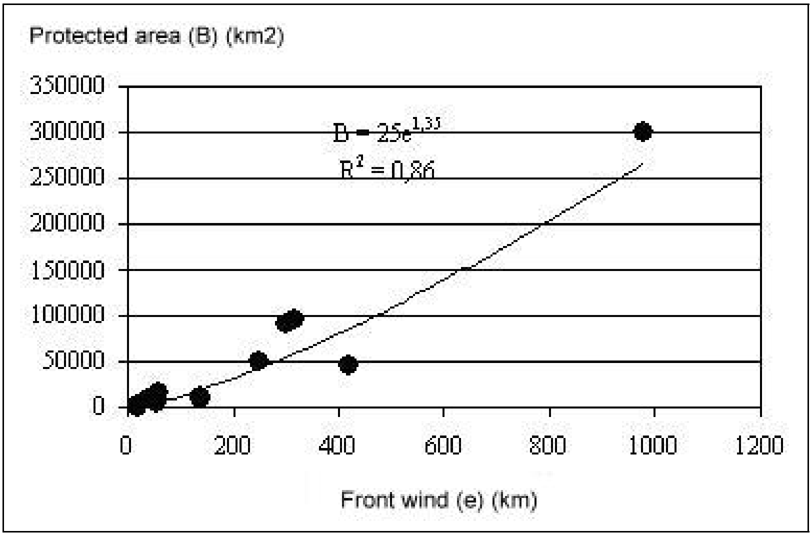


Fig. 10 Relationship between the area of shelter and face the wind

3.2.3 Effect of average altitude of the massif (H)

According Mainguet M. et al. (1983), the average height parameter (h) is not significant as barriers to same altitude have the same influences (Adrar des Ifoghas and Ader Doutchi example). In this assumption, we tried to see the effect of altitude on the mountain area of shelter. The **Fig. 11** shows the panel area shelter according to the average height of the obstacle for a dozen massive Sahara and Sahel.

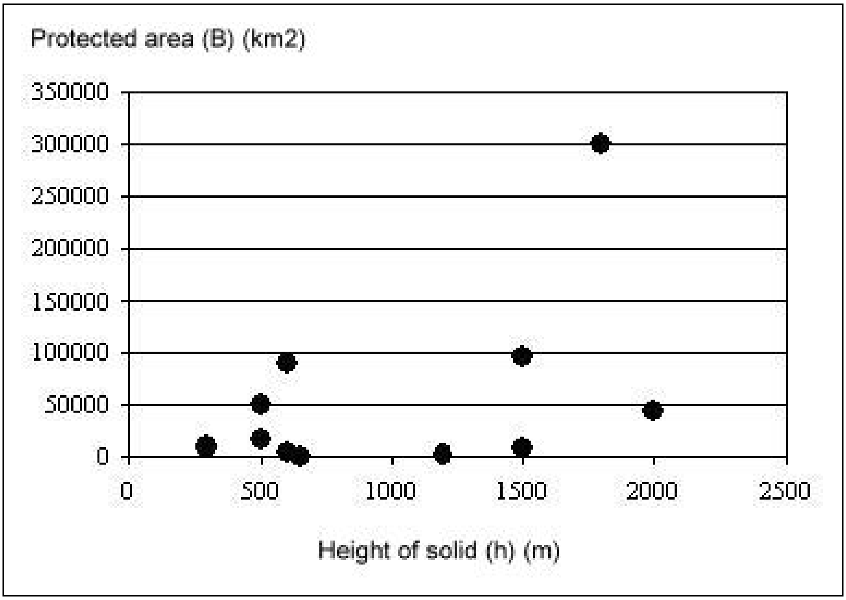


Fig. 11 Relationship between the area of shelter and the height of the obstacle

The cloud of points obtained represents no correlation and therefore the assumption Mainguet M. et al. (1983) is well verified. However, the parameter that we considered significant and has an impact on the size of the area of the shelter area is undoubtedly the mean area and the prevailing wind that we have designated with the letter B'. It is equal to: **B'=h×e**

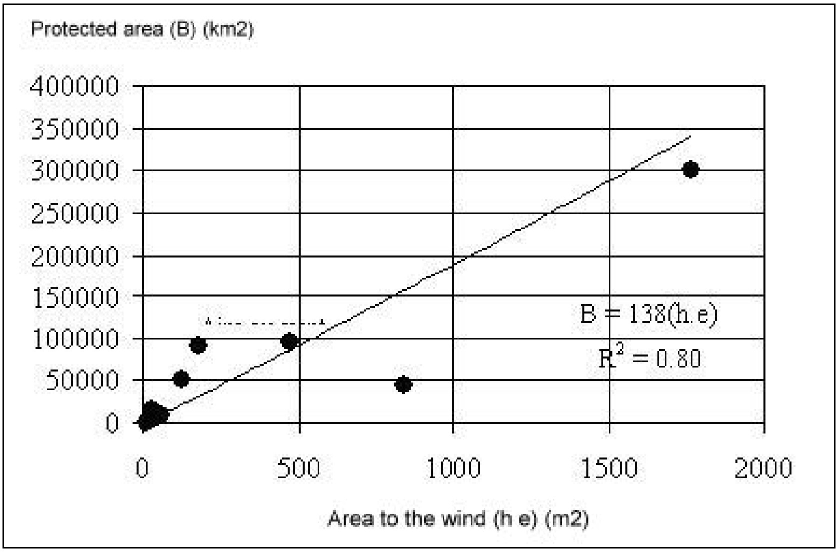


Fig. 12 Relationship between the area of shelter and the area to the wind

The **Fig. 12** illustrates the change in the area of shelter based on the average area to the wind (B '). It is interesting to note that the cloud of points takes the shape of the power function: **B = 138 (h.e)**

Over the mean area facing the wind increases, the area could cover that forms downstream of a large mass.

3.2.4 Effect of the shape of the obstacle

According Mainguet M. et al. (1983), the shape of the obstacle and its orientation relative to the wind circulation have an influence on the area of the shelter formed by the barrier. Indeed, the triangular barriers have a larger area of shelter if their base is at the upper-wind (Koutous) and not their top (Tibesti). Circular barriers are also effective in the genesis shelter areas. From the observation made from Meteosat satellite images, the nominal diameter of the obstacle (Dn) was calculated using the coefficient of form "C" and the maximum length "L" as solid relationship with: $\mathbf{D_n = L \times (C)^{1/2}}$

The **Fig. 13** shows the variation of the area of shelter based on the nominal diameter Dn. It is interesting to note that the clumps that have an important nominal diameter have a larger area of shelter, in the case of the Hoggar massif - Tassili with a diameter of 510 km, followed by the Tibesti with a diameter equal to 450 km. The correlation between two parameters area shelter and nominal diameter is the power function: $\mathbf{B = 35.D_n^{1.4}}$

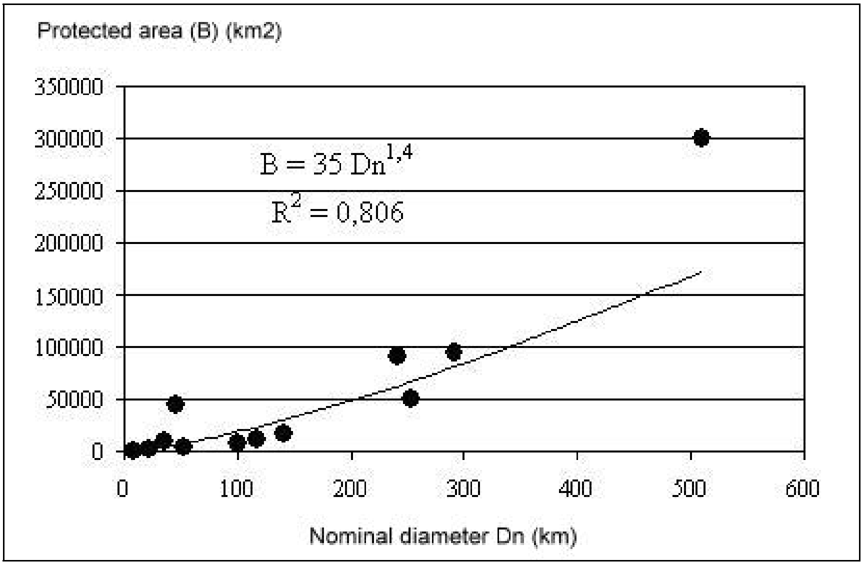


Fig. 13 Relationship between the area of shelter and the nominal diameter of the obstacle

CONCLUSION

The size and shape of the shelter area, area devoid of sand located downstream of a mega wind barrier depends mainly on the geometric configuration and read the wind profile of the massif. Indeed, the results obtained in this study show that the evolution of the area of shelter is a marked correlation with the size, shape, elongation, flattening of the massif, the windward side and front to wind. Cons by an average altitude of the massif slightest influence the formation of the shelter area.

Areas of shelter formed by the mega-challenges of the Sahara and Sahel different from an obstacle to another. The area of shelter formed by the set-Tassili Hoggar is seven times larger than that formed by the Tibesti massif, and three times larger than Eglab. The arrangement of the rock mass plays an essential role in the formation (deposition) and shaping (surface) of ergs. The size, shape and position of the obstacle relative to the prevailing wind has a great influence on the shape and dimensions of the area of shelter. Recirculation areas due to massive Sahara and Sahel have to show a correlation between the size inversely proportional to the obstacle and the area of shelter. However, this correlation showed that the parameter size is not significant in itself. The average altitude setting is also very little, because of obstacles even altitude have different influences. The front wind parameter seems more decisive, thus explaining the differences in correlation between the Adrar-Ifoghas Doutchi Ader, Hoggar-Tibesti and Tassili.

REFERENCES

Lencastre A., (1984), *Manual Hydraulic general*, Eyrolles, 411 p.

Mainguet M., Remini B., (2004), *The role of mega-obstacles in the formation and shaping of ergs*. Larhyss journal, No. 3, June, pp. 13-23.

Mainguet M., Road M.Ch., Borde J.M., (1983), *Study of the role of topographic obstacles in the wind circulation from satellite images and aerial photographs of the continental scale to that of the outlier*, Mediterranean Remote Sensing III, pp.11-19.

Remini B., (2001), Ph.D. from the University of Reims Champagne - Ardenne Humanities - Geography Option (Credit: Rt Hon), University of Reims, June.

Remini B., Mainguet M., (2004), *The morphological parameters of the mega-challenges*, Journal of Water and Environment (Algeria), No. 4, June, pp. 49-58.

Purple P.L, Chabart J.P., Esposito P., Laurence D., (1998), *Applied fluid mechanics - Incompressible flows into the channels, canals and rivers around structures and in the environment*. Editions Presses de l'Ecole Nationale des Ponts et Chaussées.