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# A study of sand sediments

Rogobete Gheorghe [1] Grozav Adia[1]

**Abstract: The vast expanse of deep Aeolian sand covering parts of the central African plateau is sands. Having endured an 80-million – year drought, the planet's oldest desert has had ample time to evolve its 300 – meter sand slopes. Other major areas are Sahel region of Africa, Sahara desert, Saudi Arabia, Registan Desert (Afghanistan), Taklimakan Desert (Xinjiang China), Simpson Desert – South Australia, Coastal dunes, litoral and lacustrine sands of beach ridges, lagoons, deltas and lakes. In addition, sands are found on weathered coarse – grained rocks. The whole coverage would be about 10 percent of the land surface. In our country, the sand covered an area of about 400000 ha. A great area with sand is situated under soil profiles, in a layer of about 800-1600 meters thickness. Finer grained material, commonly clay and silt, but sometimes including sand and coarser material, is carried along with the fluid in "suspension". Coarse grained material tends to move in intermittent contact with the bed a process called "saltation". Sand moved by waves is readily moulded into ripples, which have straight crests, which may be rounded or quite cuspate in profile. Wind blowing over dry sand, initiates movement in much the same way as water. The result is that sands tend to be very well sorted and also well rounded. Vigorous wind transport commonly leads to the development of larger bedforms, "aeolian dunes". Where sand supply is insufficient for the substrate to be fully coveres "barchans dunes" or, more rarely, "linear dunes" occur. In sand seas, a variety of more complex forms occurs. "Liquefaction" is the loss of shear strength of a saturated cohesionless soil due to increased pore water pressures. If the upward velocity of flow increases beyond this critical hydraulic gradient, then a quick condition develops and the soil begins to boil more and more violently. At such a point structures fail by sinking into the quicksand. Aeolian deposits include sand seas and dune fields, deposits of silt (loess), and fine – grained material. Romanian Soil System Taxonomy (SRTS – 2003, 2012) includes in Psamosol type the soil that has less than 12 percent clay in the first 50 cm, and the sand is aeolian. Psamosol (Arenosols) are very permeable and have rapid infiltration high hydraulic conductivity and low water holding capacity organic matter and nutrients.**

**Keywords: sand, sedimentary, erosional, aeolian, depositional.**

## 1. INTRODUCTION

The present aspect of Earth configuration represents a fleeting geological moment, having existing for no more than 4 million years, a mere 0.01 percent of the planet's lifetime. Eart's 4.57-billion-year history can be reconstructed from the shreds and patches of rock that adorn its crust, for here, layer by sedimentary layer. Nature has written her own chronology.

Plate tectonics suggests that Earth's thin crust float on the mantle and is broken into 15 ore more plates. Each plate is free to move and has three possible modes of interaction with its neighbours: convergent, divergent and transform. From these simple relationships all of geology is spawned: convergent plates buckle sheets of rock into mountain folds, ignite volcanoes and dig deep ocean trenches; divergent plates create mid-ocean ridges and ultimately, new oceans; and transform plates produce earthquakes. The power source for all this activity is believed to leak from an 8 kilometer ball of uranium at the centre of the planet. [2]

The tectonic revolution has brought the lithosphere to life – serried ranks of mountains mass at the frontline of tectonic battlefields; dislocates massifs stranded on opposite ocean shores stand as monuments to Pangaea's or Gondwana's long – lost supercontinental bulk; Precambrian granites – the scarred veterans of a billion years of erosion and the tectonic mill – huddle at the centre of the continents; the fossilized igneous umbilicals of long – extinct volcanoes rear above desert sands. Earth's geological history is a many – leaved volume, written by erosion, layer by sedimentary layer, in silt and sand on the ocean floor. Here, tectonic convulsions have seized thinly bedded sheets of sandstone, siltstone, and limestone; thrust them back to the surface.

The vast expanse of deep Aeolian sand covering parts of the central African plateau between the equator and $30^0$ southern latitude is the largest sand body on Earth. Popularly known as the Kalahari Sands, it is bordered by the Congo river in the north and the Orange river in the south. On the edge of the Kalahari Desert, parallel waves of sand dunes encroach once – fertile lands. Having endured an 80-million – year drought, the planet's oldest desert has had ample time to evolve its 300 – meter sand slopes. Other major areas are found in the Sahel region of Africa, various region in the Sahara desert (deep underground, it conceals another ocean: steeped in ice – age meltwaters, this porous stone hold over 100000 cubic kilometers of fresh water), Saudi Arabia –

[1] Faculty of Civil Engineering, Departament of Hydrotehnica, George Enescu Street No. 1/A, 300022, Timişoara, e-mail: adiagrozav@yahoo.com

Largest sand sea of Earth (in an area the size of France), each peripatetic ridge can span un to 200 kilometers with crests that peak over 300 meters, Registan Desert (Afghanistan) – here, the wind-driven migration of a barchans swarm engulfs the Registan Desert, before coalescing into a series of ridges that extend for hundreds of kilometers, Taklimakan Desert (Xinjiang China) – home to Earth's largest barchans dunes; Simpson Desert – South Australia (longitudinal sand ridges is interrupted by the salt – crusted phantoms of evaporated lakes), Coastal dunes, litoral and lacustrine sands of beach ridges, lagoons, deltas and lakes. In addition, sands are found on weathered coarse – grained rocks, mainly sandstone, quartzite and granite. The whole coverage would be about 10 percent of the land surface ~ 1 billion ha.[1,6]

Figure 1 Distribution of sand deposits [10]

In our country, the sand covered an area of about 400000ha, predominantly in Campia Oltenia (170000ha). In the west of Romania in so-called Campia de Vest, the sand covered about 26000ha (in Timis county only 3000ha). But it is necessary to underline, that a great area with sand is situated under soil profiles, in a layer of about 800-1600 meters thickness (for example in Banat region: Dealurile Lipovei, Dealurile Lugojului, Depresiunea Ezeris – Caransebes, Culoarul Timis - Cerna).[8,11]

## 2. MATERIALS AND METHODS

This article deals with some of the processes involved in sediment erosion, with features that are present where overall accumulation has occurred or could occur, with erosional surface forms, sediment transport and deposition, dunes, sand waves and cross – bedding, post – depositional sedimentary processes (like quicksands and liquefaction), Aeolian processes and also with Arenosols and Psamosols (concept and morphology properties). For some sandy soil profiles and sand deposits, we present the analytical data and the possibilities to use.

## 3. RESULTS AND DISCUSSIONS

When water or air flows over a bed of loose particles, the boundary shear stress caused by the moving fluid tends to initiate particle movement. For sediment of rather uniform grain size, the critical shear stress will increase as the grain size increases. Erosional sole marks are relatively small – scale structures preserved as casts on the bases of sandstone or, more rarely, limestone beds usually in interbedded sandstone / mudstone sequences. They vary in style and are valuable indicators of erosional and depositional processes. Such surges, which decelerated through time, typically occur as turbidity currents in deep water, as storm surges in shelf settings, and as flood events in deltaic and alluvial settings. If the transported clasts are sand and silt abrasion will augment and accelerate fluid scour. ''Wind ridges'' occur where strong winds blow across damp sand on a beach. As the sand dries out differentially, dry sand is set in motion by the wind, whilst damper patched retain some coherence and resist erosion.

Excluding highly concentrated sediment – water mixtures, sediment is transported by fluid in two distinct ways. Finer grained material, commonly clay and silt, but sometimes including sand and coarser material, is carried along with the fluid in "suspension". Coarse grained material tends to move in intermittent contact with the bed a process called "saltation". Sand particles in saltation set other grains in motion as their kinetic energy is dissipated, a process especially important in wind – blown transport. When sand starts to move, the surface becomes covered by "current ripples", small – scale, repetitive, asymmetrical bedforms, a few centimetres high and a few tens of centimetres in wavelength.

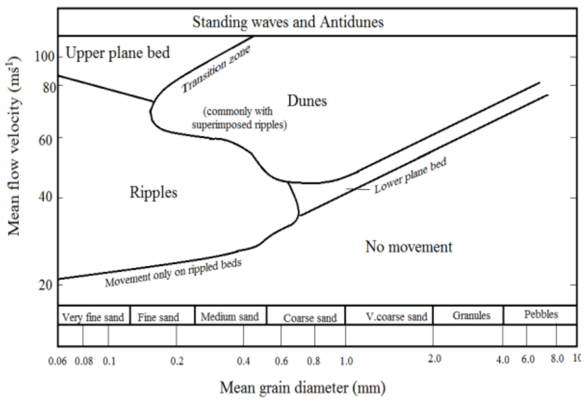


Figure 2 A plot of dtream power vs. grain size showing the field of occurrence of the main classes of bedform produced by unidirectional water flows [4]

As current velocities increase above those appropriate for ripples, sand beds deform into larger bedforms, termed "dunes" or "sand waves", provided that the water is deep enough. Large volumes of sand must be moved to remould large forms and, in rivers where discharge varies quickly or in tidal settings, large – scale bedforms are often in a state of disequilibrium. Sand moved by waves is readily moulded into ripples, which have straight crests, which may be rounded or quite cuspate in profile. [7]

Wind blowing over dry sand, initiates movement in much the same way as water. The result is that sands tend to be very well sorted and also well rounded. The first bedfoms to develop on dry sand are ripples. These have low relief compred with aqueous current ripples and are less clearly asymmetrical. Vigorous wind transport commonly leads to the development of larger bedforms, "aeolian dunes". Dunes vary greatly in both scale an shape.

Where sand supply is insufficient for the substrate to be fully coveres “barchans dunes” or, more rarely, “linear dunes” occur. In sand seas, a variety of more complex forms occurs. These include transverse dunes, barchanoid forms, and star – shaped dunes. Internally, dune sands show complex cross-bedding at scales up to many metres thick. [5]

Many sandstone beds in interbedded sandstone – mudstone successions show an internal sequence of lamination types that are diagnostic of decelerating flows.

Powerful water currents also transport gravel, and its deposition can lead to distinctive structures and fabrics.

Early formed soft – sediment deformation structures are typically features of sandstones and finer sediment. Deformation occurs within sediment when intergranular forces are unable to resist applied stresses, which are usually gravitational. The shear strength is normally expresses by the equation:

$$\tau = C + (\sigma - p)\tan\varphi$$

where $\tau$ is the shear strength, C is the grain cohesion, $\sigma$ is the pressure normal to shear, p is the excess pore fluid pressure, and $\varphi$ is the angle of internal friction.

In both cohesive and non- cohesive sediments, high pore water pressure commonly leads to a loss of shear strength. Rapidly deposited sands, lacking significant fine – grained sediment, commonly have rather loose grain packing. They are particularly susceptible to shock, such as by an earthquake, heavy wave action, or a sudden rise in water level. “Liquefaction” is the loss of shear strength of a saturated cohesionless soil due to increased pore water pressures and the corresponding reduction in effective stress during cycle loading. As a saturated cohesionless soil is cyclically loaded, its particle structure can tend to colappse to a denser arrangement. If the soil’s permeability and the site stratigraphy are such that drainage cannot occur immediately, then, as the collapse occurs, stresses will be transferred from the soil grain contacts to the pore water, leading to an increase in pore water pressure. In simple terms, when the pore water pressure increases, the effective stress (total stress minus pore water pressure) on the particle structure will reduce, and as it approaches zero, the shear resistance of the soil will also approach zero. [3]

The potential for liquefaction to cause damage is assessed in three stages: the susceptibility to liquefaction, the likelihood of liquefaction being triggered by the design earthquake scenario and the consequences related to liquefaction.

As water flows through sands or silts and slows down, its energy is transferred to the particles past which it is moving that, in turn, creates a drag effect on the particles. If the drag effect is in the same direction as the force of gravity, then the effective pressure is increased and the soil is stable. Conversely, if water flows towards the surface, then the drag effect is counter to gravity, thereby reducing the effective pressure between particles. If the upward flow velocity is sufficient, it can buoy up the particles so that the effective pressure is reduced to zero. This represents a critical condition where the weight of the submerged soil is balanced by the upward acing seepage force. If the upward velocity of flow increases beyond this critical hydraulic gradient, then a quick condition develops and the soil begins to boil more and more violently. At such a point structures fail by sinking into the quicksand. Liquefaction of potential quicksands may be brought by sudden shocks caused by the action of heavy machinery, blasting and earthquakes. Aeolian processes, involving erosion, transportation, and deposition of sediment by the wind, occur in a variety of environments, including beaches, semi-arid and arid regions, agricultural fields. There are three modes of sediment transport by wind: creep or reptation (particles >500 μm), saltation (particles 63-1000 μm), and suspension (particles <20 μm). Aeolian deposits include sand seas and dune fields, deposits of silt (loess), and fine – grained material that forms a significant component of desert margin and other soils.

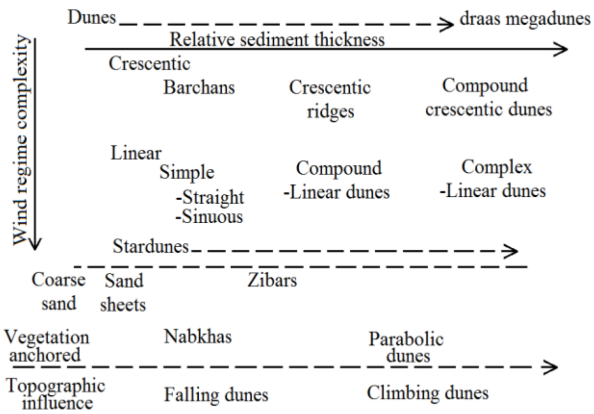

Figure 3 Morphological classifications of Aeolian sand dunes [4]

Linear dunes are characterized by their length (often more than 20 km), sinuous crestline, parallelism, and regular spacing. Star dunes have a pyramidal shape, with three or four sinuous sharp – crested arms radiating from a central peak, and are the largest dunes in many sand seas, reaching heights of more than 300m. Parabolic dunes are characterized by a U or V shape with a “nose” of active sand and two partly vegetated arms that trail upwind. They are common in many coastal dunefields and semi – arid inland areas.

Many aeolian deposits and landforms formed during the Quaternary Era, thus they have been affected by climatic and sea-level changes associated with glacial – interglacial cycles. The changes in system state are manifested as episodic accumulation of aeolian deposits, resulting in sequences of loess accumulation interspersed by palaeosols, or formation of different dune generations in aeolian sand seas and dune fields.

Arenosols (WRB) are soils with a texture that is coarser than sandy loam to depth of at least 100 cm from the surface, or to a Plinthic, Petroplinthic or

Salic horizon and having less than 35 percent of rock fragments.

Romanian Soil System Taxonomy (SRTS – 2003, 2012) includes in Psamosol type only the soils that has less than 12 percent clay in the first 50 cm, and the sand is aeolian. [9,10]

Analytical data – Psamosol (Arenosols) – Lovrin
Table 1

| | **Ap 0-23cm** | **Am -43** | **C -95** |
|---|---|---|---|
| pH | 4.97 | 5.00 | 6.24 |
| Sand | 64.7 | 84.6 | 86.9 |
| Silt | 5.0 | 3.8 | 3.6 |
| Clay | 10.3 | 12.0 | 11.3 |
| K $mm \cdot h^{-1}$ | 16.0 | 21.0 | 11.6 |
| Humus | 2.73 | 2.42 | - |
| BSP | 56.7 | 61.3 | 83.3 |
| CECs | 13.6 | 9.3 | 2.4 |

Psamosol (Arenosols) are very permeable and have rapid infiltration high hydraulic conductivity and low water holding capacity. There may be large variations in the content of organic matter and nutrients. CEC ranges from very low to moderate level; pH and base saturation are very variable.

In arid areas Arenosols are predominantly used for extensive grazing. Vegetative growth reacts much faster in the sandy areas than in areas with finer-textured or shallow soils, as the little rain than falls occasionally, in much more effective. Where rainfall exceeds 400-500 mm per annum, Arenosols can be used for rainfed cultivation.

Successful dryland or irrigated cropping of Arenosols in semi-arid to sub-humid areas requires well – adapted management practices. The main problem on these soils is their extreme vulnerability to wind erosion, which needs to be controlled by means of wind breaks.

Furthermore, the well-sorted, well – rounded fine sandy aeolian, Arenosols are extremely vulnerable to soil compaction, i.e. the development of “traffic pans”, under intensive mechanized farming.

## 4. CONCLUSIONS

Eart’s 4.57-billion-year history can be reconstructed from the shreds and patches of rock that adorn its crust, for here, layer by sedimentary layer. In our country, the sand covered an area of about 400000ha, predominantly in Campia Oltenia (170000ha). In the west of Romania in so-called Campia de Vest, the sand covered about 26000ha (in Timis county only 3000ha). But it is necessary to underline, that a great area with sand is situated under soil profiles, in a layer of about 800-1600 meters thickness (for example in Banat region: Dealurile Lipovei, Dealurile Lugojului, Depresiunea Ezeris – Caransebes, Culoarul Timis - Cerna).

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[12] ***, Studii pedologice OSPA, Timisoara;