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Deposits of Quartz Sands in Somalia

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Х. Каранов — Находища на кварцови пясъци в Сомалия. Кварцовите пясъци изграждат горната част на нубийската серия в Северозападна Сомалия и имат алувиално-делтов произход. В естествено състояние те отговарят на всички изисквания на стандартите за най-високите класове и групи формовъчни пясъци. След обогатяване те са подходящи за производството на всички видове стъкла. В приповърхностните части на находищата, където покривката е по-малка, има достатъчни количества кварцови пясъци, на базата на които се препоръчва развитието на кариери, строителство на обогатителна инсталация и фабрика за производство на домакинско стъкло. При добива част от същите пясъци могат да се използуват без обогатяване в леярството.

Introduction

The first geological investigations in Northwest Somalia date back in the 20-ies of our century when the attention to this area was focused by information on the presence of oil. At that time were published the works of Farquharson (1924) and Macfayden (1933) who described for the first time the Nubian sandstones. Later, in 1953 - 58, with the help of English geologists, the Geological Society of Somalia carried on geological mapping in Nortwest Somalia in scale 1:125 000. The area of Hargeisa-Berbera which includes the region studied was covered by geological map with explanatory text (Mackay, 1954; Hunt, 1857, 1958, 1960; Mason, 1956, 1962). All geological formations were described in detail and Mason (1962) noted that the Nubian series contained sands which conformed to the requirements of glass industry. The Auradu limestones were referred to the Lower Eocene and the Boulder Beds — to the Neogene. In the period 1974-76 the geological investigations of the area were extended and became more profound with the studies of the United Nations and the Soviet geological expedition (unpublished reports of UNDR-Phase III, 1975; Orlov, 1975, 1976). In that period S. Trashliev and B. Kamenov, on the basis of literature evidence for the Nubian series and personal field observations, suggested to organize geological prospecting and evaluation of the quartz sands in this area (unpublished reports of Trashliev, 1975; Kamenov 1975; Trashliev & Kamenov, 1974, 1975, 1976). For this purpose, in 1977 - 78 a team of bulgarian experts with the aid of somalians carried out prospecting and preliminary exploration of the quarts sands from Hargeisa to Gaan Libahh in Northwest Somalia. As a result of these investigations a number of occurrences and deposits of quartz sands were discovered which are described in detail in the geological report of Karanov, Vodenicharov and Mikhai-

lov (unpublished report, 1978). The results of laboratory investigations by Ruskova (granulometric and mineralogical), Slavov (chemical), Zlatanov, Pironkov and Sekulov (dressing) and Popov, Karamanov and Pavlova (glass production), presented in this report, are used in the present paper.

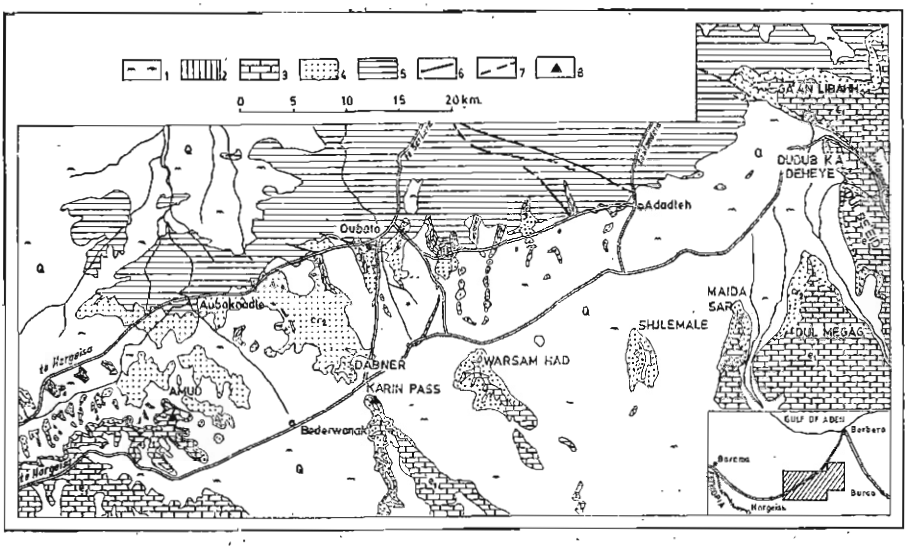

Fig. 1. Geological map of the area Amud-Gaan Libahh, Northwest Somalia
1 — alluvium; *2* — Boulder Beds; *3* — Auradu limestones; *4* — Nubian series; *5* — metamorphic and magmatic rocks; *6* — established normal faults; *7* — assumed normal faults; *8* — deposits of quartz sands

These studies in Somalia for the first time establish the occurrence of high-quality glass and mould quartz sands which supplies the grounds for a future very perspective industry in this country.

Brief geological characterization

The region studied (Fig. 1) is made up of metamorphic and magmatic rocks (rocks of the basement) which are overlain by kaolinite weathering crust — Lower Cretaceous (after Trashliev, 1977), the Nubian series — Upper Cretaceous, Auradu limestones — Lower Eocene, Boulder Beds — Neogene, alluvium and deluvium according to Hunt (1960) and Mason (1962).

The Nubian series is widespread in the region studied. Its northern boundary extends from Hargeisa through Aubakhadle, Dubato, Adadleh, Gaan Libahh and continues to the east outside the region. Its southern boundary follows the slopes of the hills Amud, Karin Pass, Warsam Had, Shjemale, Maida Sar, Dul Megag, Dul Be'eid, Dubub Ka Deheye and at Geen Libahh joins the northern boundary.

The Nubian series overlies transgressively and unconformably the rocks of the basement and the kaolinite weathering crust which in places is washed out. Usually the section begins with a basal conglomerate 0.1 - 0.3 m in thickness made up of rounded red and white quartz and pegmatite pieces (Fig. 2). In places this conglomerate is replaced by compact, coarse-grained yellow sandstone. It is followed upwards by compact, grey fine-grained sandstones in places with cross-bedding, 5-7 m thick. The section continues with a forma-

tion of loose fine-, medium- and coarse-grained, yellow, red and dark-violet sandstones, 150-200 m in thickness which contain rare interbeds of fine conglomerates and grittstones (outcrops are lacking for part of the section). In the lower part of this formation the so called "Dubato clays" (H u n t, 1958) occur with thickness from 0.3-0.5 to 7-8 m, followed upwards by interbeds of very strong, ferruginized quartzite-like sandstone 0.5-2 m thick. This varied formation is overlain by white, grey-white, yellowish or light-violet loose sands to sandstones (20-40 m), rarely with interbeds of multicoloured sandstones (0.5-2 m). These sandstones were covered by the geological investigations carried out. The section of the Nubian series ends with grey-violet and rusty-yellow, in places clayey sands (5-10 m) with interbeds of grey-yellowish compact clays (5-30 cm).

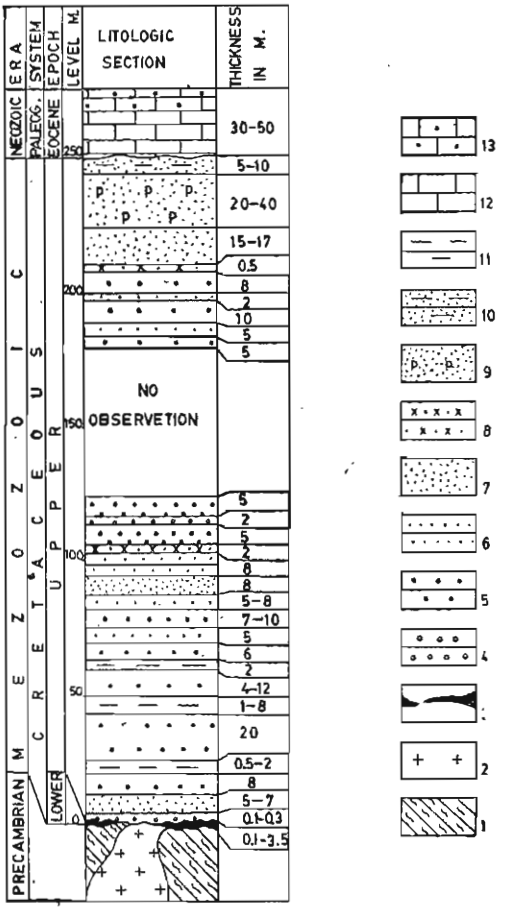

Fig. 2. Lithologic-stratigraphical coloumn of the Nubian series in the area Amud-Gaan Libahh

1 — metamorphic rocks; *2* — magmatic rocks; *3* — kaolinite weathering crust; *4* — conglomerates and grittstones; *5* — coarse-grained sandstones; *6* — medium-grained sandstones; *7* — fine-grained sandstones; *8* — quartzite-like sandstones; *9* — loose sands to sandstones (Industrial sands); *10* — sands with clay interbeds; *11* — clays; *12* — limestones; *13* — limestones with flint

The geological investigations of the Nubian series discovered the occurences east of Hargeisa, Dabner, Dul Megag, Maida Sar and Dubub Ka Deheye and the deposits Amud and Karin Pass (Fig. 1). Apart from the already established occurrences and deposits all outcrops of the upper part of the Nubian series are of particular interest where other new deposits may be searched for.

The Auradu limestones crop out along the higher parts of the hills mainly south of the Hargeisa-Mogadisho motor road. They overlay without visible angular unconformity the Nubian sandstones. The base comprises grey-white nodular limestones which upwards grade into massive limestones with flint concretions up to 10 cm in size. The thickness of Auradu limestones is 30-50 cm.

The Boulder Beds form the tops of many hills east of Hargeisa through Dubato and Debis to Adadleh between the Hargeisa-Mogadisho and Hargeisa-Berbera motor roads (Fig. 1). Usually they overlay sandstones from different horizons of the Nubian series and less commonly cover directly the basement rocks. The Boulder Beds are made up of re-deposited rounded pieces of Lower Eocene limestones (5 cm to 1.5 m in size) and few pieces of quartzitelike sand-

stones from the Nubian series. The cement is sandy-carbonate. The thickness varies from 15 m to 25 m.

The Quaternary sediments are of wide occurrence particularly in river valleys and have a thickness of 5-10 and more meters. The alluvial sediments

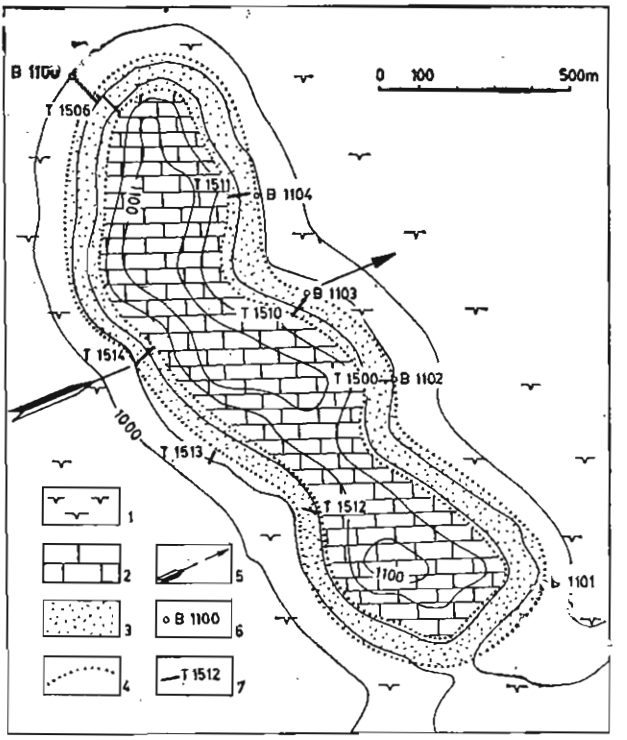

Fig. 3. Geological map of Karin Pass deposit

1 — alluvium; *2* — Auradu limestones; *3* — sandstones (Upper Cretaceous); *4* — geological boundaries; *5* — cross-section lines; *6* — borehole and its number; *7* — trench and its number

are represented mainly by sands and the deluvial — by pieces of different size ranging up to boulders. Commonly the deluvial materials overlaying the Nubian series on hill slopes have carbonate cement and from rather strong crusts-0.2-1 m thick.

Geology of Karin Pass deposit

The Karin Pass deposit is located south of the fork of the old road from Hargeisa to Burao and Dubato (Fig. 1). The deposit is an elongated in NW-SE direction hill which elevates about 100 m above the surrounding plain. The base of the hill is made up of sediments of the varied formation of the Nubian series. They are overlain by the industrial quartz sands (16-25 m thick), followed by coloured quartz sands (5-12 m) with clayey interbeds and Auradu limestones (50 m) (Fig. 3, 4). The beds are nearly horizontal, sloping at 1-2° to the south.

The quartz sands are loose to very weakly compacted, white, grey-white or light-violet. Rarely they contain interbeds of violet-red sands several mm

to several cm in thickness, nodules of grey clays 2-5 cm in size and concretions of quartzite-like sandstones up to 10×20 cm in diameter.

The quartz sands are mainly fine-grained in the base and the upper part of the section, and fine to medium grained in the middle part of the deposit.

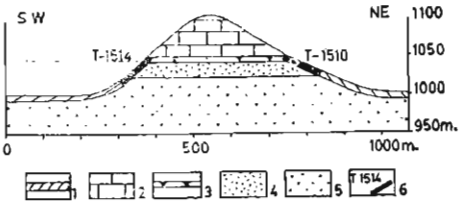

Fig. 4. Geological cross-section of Karin Pass deposit

1 — Alluvium; *2* — Auradu limestones; *3* — coloured quartz sands with clay interbeds: *4* — white quartz sands sands (industrial sands); *5* — coloured quartz sands; *6* — trench and its number

Due to different granulometric composition of the individual layers the maximum and minimum content of the samples vary in a wide range but the average content is rather constant (Table 1) which is favourable for mass production from a future quarry. According to granulometric composition the sands are suitable for use in glass and moulding industry.

The mineral composition of the sands in the whole deposit is constant. The mineralogical studies of the industrial fraction (0.1-0.63 mm) show that they are almost pure quartz sands. Most of the quartz grains are colourless and transparent, highly rounded to spherical, commonly with mirror polished walls. In the lower fraction (0.1-0.2 mm) some of them contain fine inclusions of zircon, tourmaline and ore minerals of iron-oxide type. In rhe light fraction, apart from quartz, single grains of albite, muscovite, biotite, clay minerals, microgranular calcite and aggregates of silty to pelitic quatz grains with calcareous or iron-hydroxide cement are found. It is interesting to note the occurrence of worm-like individuals of kaolinite which, with their crystal habitus (well formed worm-like crystals), indicate diagenetic processes expressed in the formation of authigenic mineral phases. The heavy fraction is less than 0.5% in respect of the light fraction. It contains a characteristic association of stable minerals with highly rounded crystal forms and constant quantitative relations between each other. It is composed of zircon, rutile, tourmaline, kyanite, garnet, epidote-zoisite minerals, ore minerals, leucoxene, hematite, ilmenite and anatase. The typomorphic mineral is kyanite which, as a typical metamorphic product, indicates participation of sources with metamorphic origin.

Table 1

Granulometric Composition of Quartz Sands

Content	Fractions in mm/content of fractions in per cents											
	<0.01	0.01—0.1	0.1—0.2	0.2—0.3	0.3—0.5	0.5—0.63	0.63—0.8	0.8—1	1—2	2—3	3—10	>10
Minimum	0.36	0.58	5.55	3.84	1.10	0	0	0	0	0	0	0
Maximum	6.55	6.25	88 60	34.93	54.82	17.69	9.57	10.39	9.56	3.38	1.87	0.2
Average	1.35	2.93	42·60	18.38	24.06	4.84	2.53	1.24	1.58	0.36	0.13	0

Table 2

Chemical Composition of Quartz Sands

Content	Chemical composition in per cents							
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O
Minimum	97.0	0.51	0.03	0.05	0.07	0.01	0.01	0.01
Maximum	98.8	1.50	0.30	0.32	0.47	0.30	0.40	0.40
Average	98.0	0.94	0.11	0.13	0.24	0.08	0.06	0.06
Dressed quartz sand fraction, 0.1—0.63 mm	98.5	0.43	0.06	0.05	0.20	0.40	—	—

The chemical composition is studied on the basis of the washed fraction 0.1-0.8 mm in 44 samples of quartz sands collected from surface workings at Karin Pass deposit (Table 2). The table shows that the content of SiO_2 is rather high and constant in the whole deposit (in average 98%). The Fe_2O_3 content (according to data of surface workings) varies from 0.03 to 0.3%, in average 0.11%. Due to lack of boreholes it is not possible to establish if it increases in depth as is the case of the adjacent deposit of Amud where the Fe_2O_3 content ranges to 0.86% (in average 0.20%) in depth. The TiO_2 content varies from 0.05 to 0.32%, average 0.13%, and the other components are in very small amount and in fact do not influence the composition and qualities of the quartz sands.

The quartz sands in Karin Pass deposit conform in natural condition to all requirements of the standarts for the highest classes and groups of moulding sands (Черносвитов, 1965; $SiO_2 \geq 97\%$, $Fe_2O_3 < 0.75\%$, $K_2O + Na_2O < 0.5\%$ and clay below 0.2%. After dressing, due to the natural very suitable for glass industry composition, a high output of glass fraction (0.1-0.63 mm=86%) was obtained. After drying the latter was subjected to electromagnetic separation with one basic and two refinement operations and an output of nonmagnetic fraction of 82% was obtained. The chemical composition of the latter shows good purity in respect of the content of colouring oxides (Fe_2O_3=0.06%, TiO_2=0.05% — Table 2). The dressed quartz sand is suitable for production of high-quality colourless packing glass (bottles, jars, etc.) as well as for all types of glass in construction works (for windows, armoured glass, etc.). After treatment with optimum amounts of chemical and physical decolourizers the dressed quartz sand is suitable for production of domestic products of potash glass (sets for water, wine, wisky, etc.).

In the near-surface parts of the deposits where the cover is thinner there are sufficient amounts of quartz sands on the basis of which development of quarries, construction of a dressing plant and factory for production of domestic glass is proposed. In the process of mining part of these sands may be used without dressing in moulding industry.

Conditions of origin

The Upper Cretaceous in the region studied is represented by the continental sediments of the Nubian series. The base is formed mainly of alluvial river facies — conglomerates, grittstones, sandstones and clays commonly with crossbedding and varying composition. The sources of the material were both older Jurassic sediments and rocks from the basement with metamorphic and magmatic origin. Upwards in section gradually develop more finer-grained

facies with interbeds of quartzite-like sandstones. The upper part of the Nubian series is represented by alluvial-delta facies with formation of pure monomineral fine-to medium-grained quartz sands of considerable areal extent and thickness.

During the transgression of the Lower Eocene sea the Auradu limestones cover with a wash-out but without visible unconformity the sediments of the Nubian series.

Deep erosion and denudation in the western part of the region took place more recently (before the deposition of the Boulder Beds) which lead to wash-outs in the whole Nubian series, the kaolinite weathering crust and part of the basement rocks. The Boulder Beds, formed afterwards, overlay both different levels of the Nubian series and directly the basement rocks.

Alluvial sediments were formed during the Quaternary. They comprise sands of the washed-out Nubian series and deluvial sediments of diverse grain size and age, commonly with calcareous cement.

The diagenetic and epigenetic processes in the Nubian series are fixed in formation of authigenic kaolinite, nodules of clays and concretions of quartzite-like sandstones.

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