Characteristics of East Belitung Silica Sand and Its Compatibility as a Strategic Industrial Raw Material

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Abstract. The Indonesian government has designated quartz sand, quartz stone and quartz crystals which are included in the silica category as critical minerals through the Decree of the Minister of Energy and Mineral Resources No 296.K/MB.01/MEM.B/2023. Intensive exploration needs to be carried out to guarantee the availability of supplies of raw materials while ensuring the compatibility of specifications for strategic industries in the country. "Project X" is an exploration area in East Belitung Regency which has abundant silica sand potential. Exploration using the hand-drilling method at 114 locations and XRF analysis of 199 sand samples was carried out to ensure the distribution and quality of "Project X" silica sand. The drilling results show an even layer of silica sand with a thickness ranging from 20 to 850 cm with peat and clay layers as a separator between the sand layers. The composition of key compounds shows that SiO_2 content ranges from 87.28 to 99.66%wt, Fe_2O_3 content ranges from 0.02 to 0.64%wt, Al_2O_3 content ranges from 0.1 to 6.36%wt, TiO_2 content ranges from 0.02 to 0.59%wt, CaO content ranges from <0.01 to 2.23%wt, MgO content ranges from <0.01 to 0.31%wt, Na_2O ranges from <0.01 to 0.48%wt, and K_2O content ranges from <0.01 to 1.06%wt. This composition is compared with the raw material criteria for a number of silica sand products on the market to determine its suitability as raw material for the related product. The comparison results show that "Project X" silica sand in natural (unprocessed) conditions can be a raw material for the industry of borosilicate glass, flat or container glass, insulating fiber, abrasive sand, refractory sand and brick, foundry sand, and silica sand filter. "Project X" silica sand needs special treatment in the form of washing and separating a number of compounds so that it can meet the criteria for more advance products such as optical and ophthalmic glass, low iron silica sand, crystal glass, and chemical sand.

Keywords: silica, belitung, compatibility

1. Introduction

The Government of the Republic of Indonesia issued the Decree of the Minister of Energy and Mineral Resources No. 296.K/MB.01/MEM.B/2023 which classifies quartz sand, quartz stone, and quartz crystals as critical minerals. This strategic policy was issued as a government response to domestic and global needs for increasing energy needs, sustainable energy transition, and Indonesia's commitment to achieving carbon emission reduction targets. Intensive exploration is needed to ensure the availability of these critical minerals. The right step to take is to inventory areas in Indonesia that have silica potential, and to characterize their potential to determine their compatibility as industrial raw materials. East Belitung Regency is an area that has silica deposits, especially silica sand.

The presence of silica sand is due to its geological conditions. Based on the Geological Map of the Belitung Sheet, Sumatra (Baharuddin and Sidarto; 1995), the regional geology is composed of Alluvium, Carboniferous Sand, Tajam Formation, Kelapakampit Formation, Siantu Formation, Tanjungpandan Granite, Baginda Adalemite, Burungmandi Granodiorite, Batubesi Quartz Diorite. The stratigraphic units consist of six formations in sequence from old to young, namely: Batubesi Quartz Diorite (Kbd), Burungmandi Granodiorite (Kbg), Baginda Adalemite (Jma), Tanjungpandan Granite (Trtg), Siantu Formation (PCsv), Kelapa kampit Formation (PCks), Tajam Formation (PCTm), Carboniferous Sand (Qpk), Alluvial and Beach Deposits (Qa).

Natasia et al. (2016) concluded that the geological structures that developed in this area include folds, faults, and fractures. The direction of the fold axis is generally northwest-southeast, while the faults are northeast-southwest. Tectonic activity began in the Permian-Carboniferous period which produced flysch sediment deposits of the Kelapakampit Formation, at the same time there was a collision that formed the Siantu Formation. In the Triassic period, magmatic activity occurred which produced Tanjungpandan Granite which carried primary cassiterite. During the early Jurassic, magmatic activity continued and resulted in the intrusion of the Baginda Adalemite rock, this magmatic activity ended in the Late Cretaceous with the formation of intrusions of diorite and granodiorite rocks. Since the Late Cretaceous to the Quaternary, erosion and deposition processes have occurred which have produced

carbonaceous sand and alluvium deposits. The erosional process produces a lot of silica sand as a product of the breakdown of silica-rich igneous rocks.

The presence of silica sand in the East Belitung area is the background for implementing the "Project X" as an exploration project to ensure the presence of silica sand deposits in the project area and determine its compatibility as an industrial raw material regulated by the government (Fig.1).

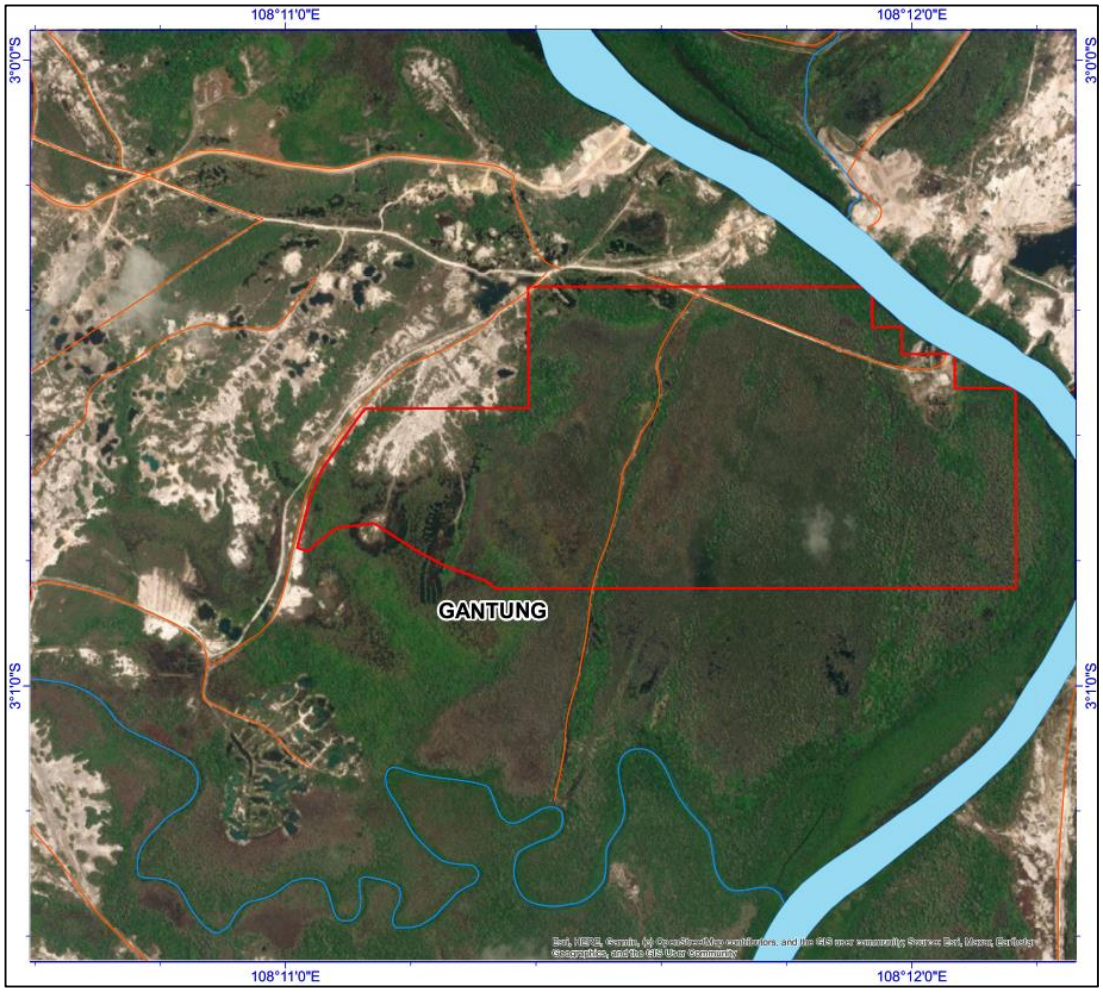

Figure 1. Situation map of "Project X" area

The "Project X" area is located in Gantung District. Silica sand in Gantung District usually spreads on the surface generally has a clean physical appearance because it is a by-product of mining and washing in community tin mines. This area is interesting because it still has not been opened and is still in original condition. It is interesting to know the characteristics of silica sand in its original condition.

2. Data and Methodology

Exploration activities carried out are divided into several stages where these stages consist of studio, field, and laboratory activities. Desktop study which is an activity to conduct a literature study approach from previous research results including the preparation of initial prospecting targets, track routes, making thematic maps, and conducting regional geological studies. Field activities consist of drilling using a hand drill to determine the subsurface lithology profile as well as sampling silica sand for laboratory analysis.

XRF as the main analysis method to determine the chemical characteristics of the silica sand sample being analyzed. Key compounds that are usually used for the suitability of the raw material being analyzed include SiO_2, Al_2O_3, TiO_2, CaO, MgO, Na_2O, and K_2O. The compatibility of the natural characteristics of silica sand in the "Project X" area is compared with the criteria for silica products

regulated by the Regulation of the Minister of Trade Number 12 of 2022 which consists of molding sand, low iron silica sand, and white silica products. There are other types of silica products that apply in the market, but in this paper they cannot be conveyed openly for reasons of data confidentiality.

Exploration drilling using the hand-drilling method at 114 locations was carried out to ensure the distribution and quality of "Project X" silica sand (Fig.2). The drilling results show an even layer of silica sand with a thickness ranging from 20 to 850 cm with peat and clay layers as a separator between the sand layers.

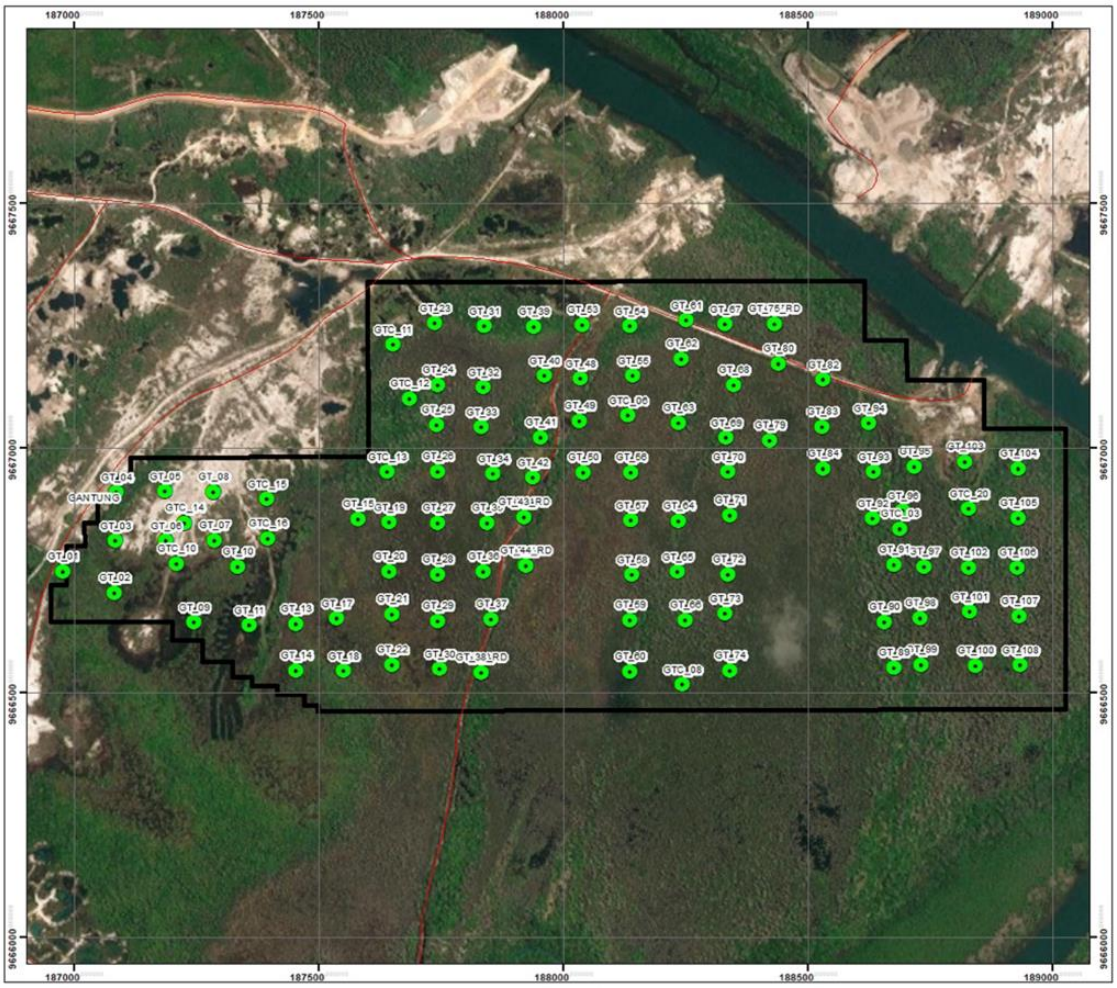

Figure 2. Drilling location distribution map

Lithology obtained from exploration drilling consists of five types of lithology, namely peat, clay, muddy sandstone, silica sand, and bedrock. *Peat* characterized by its characteristics in the form of loose material, medium-fine sand grain size, with a dark brown-black color, has vegetation fragments such as roots, leaves, and a distinctive peat aroma. *Clay* characterized by its color varying from dark brown, dark gray, to white, with clay grain size, has a characteristic of being sticky to very solid. Solid clay is one of the lithologies that inhibits the drilling process. *Muddy sandstone* (local name *basokak*) characterized by its dark brown-black color, has a medium sand grain size that is slightly sticky. Becomes one of the lithologies that inhibits the drilling process. *Silica sand* characterized by its weathered brown-forest color, with a fresh white color. In terms of physical appearance, it has a fine-coarse sand grain size, with the presence of silica minerals in the form of clear quartz, dominating. The drilling results show an even layer of silica sand with a thickness ranging from 20 to 850 cm with peat and clay layers as a separator between the sand layers. Each layer of silica sand was sampled for XRF analysis. A total of 199 silica sand layers were sampled, the results of which are shown in Figure 3. *Bedrock* characterized by compact rock, white in color, has a fine sand-coarse sand grain size, which is a limitation for drilling.

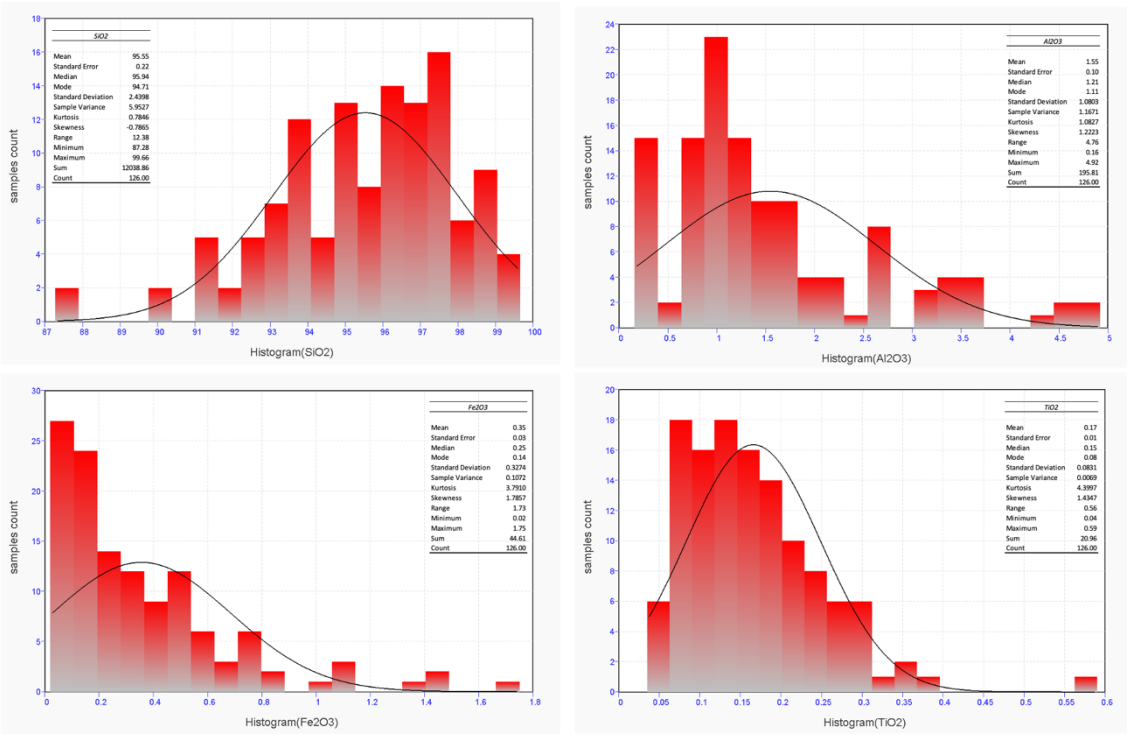

Figure 3. Histogram of SiO_2, Al_2O_3, Fe_2O_3 dan TiO_2

The composition of key compounds shows that SiO_2 content ranges from 87.28 to 99.66%wt, Fe_2O_3 content ranges from 0.02 to 0.64%wt, Al_2O_3 content ranges from 0.1 to 6.36%wt, TiO_2 content ranges from 0.02 to 0.59%wt, CaO content ranges from <0.01 to 2.23%wt, MgO content ranges from <0.01 to 0.31%wt, Na_2O ranges from <0.01 to 0.48%wt, and K_2O content ranges from <0.01 to 1.06%wt. This composition is compared with the raw material criteria for a number of silica sand products on the market to determine its suitability as raw material for the related product.

3. Results and Discussion

The results of exploration drilling and lithology characterization provide the technical basis for creating target areas in the "Project X" area. The target area of silica sand prospects is limited to three main blocks containing white sand and brown sand lithology as the main domain of the sand body, then supported by the distribution of grades that have been focused on the sand body layer (Fig.4). The area outside the three prospect blocks is dominated by clay layers, some of which are peat and basokak (muddy sandstone).

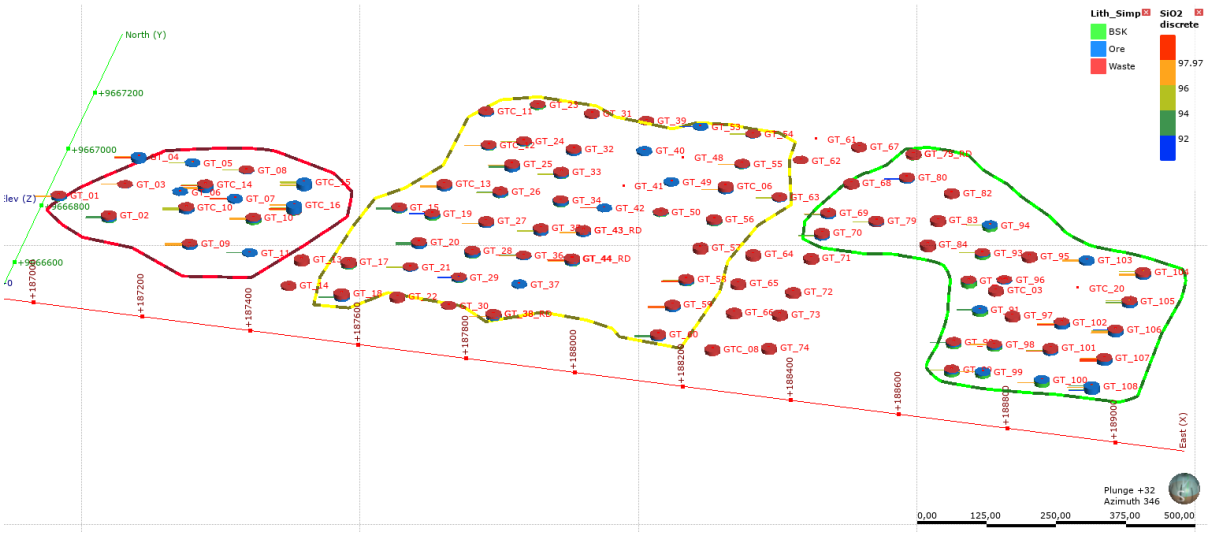

Figure 4. Map of drill point distribution and prospect areas

The chemical characteristics of the silica sand samples were compared with three silica products regulated by the government in the Minister of Trade Regulation Number 12 of 2022. This regulation generally requires criteria for three groups of silica products, namely molding sand, low iron silica sand, and white silica (Table 1).

Table 1. Compatibility of silica sand characteristics in the "Project X" to silica product criteria

Products silica products in the Minister of Trade Regulation Number 12 of 2022						
Domain	**SiO_2 (%)**	**SiO_2 (%)**	**Fe_2O_3 (%)**	**Molding Sand** (>90% SiO_2)	**Low Iron Silica Sand** (>99,5% SiO_2; <120 ppm Fe_2O_3)	**White Silica** (>95% SiO_2)
PROSPECT 1	92~94	93.66	0.36	Compatible	Incompatible	Incompatible
	94~96	95.18	0.27			Compatible
	96~98	96.83	0.17			
	98~100	98.02	0.16		Fe separation needed	
	Avg	**96.04**	**0.22**			
PROSPECT 2	88~90	89.56	0.91	Incompatible	Incompatible	Incompatible
	90~92	91	0.73	Compatible		
	92~94	93.28	0.55			
	94~96	95.02	0.4			Compatible
	96~98	96.92	0.16			
	98~100	98.08	0.07		Fe separation needed	
	Avg	**95.15**	**0.36**			
PROSPECT 3	90~92	91.39	0.21	Compatible	Incompatible	Incompatible
	92~94	93.43	0.61			
	94~96	95.13	0.55			Compatible
	96~98	96.63	0.31			
	Avg	**95.24**	**0.5**			
Avg		**95.47**	**0.36**			

The comparison results show that “Project X” silica sand in natural (unprocessed) conditions can be a raw material for molding sand and white silica. The general characteristics of silica sand in the "Project X" are the Fe_2O_3 content which exceeds the maximum limit of the product criteria, and the proportion of SiO_2 which is not yet maximum due to the presence of non-silica compounds which are still included in the silica sand. Other references refer to the paper by Okereafor et al. (2020) compared separately to determine the compatibility criteria show that the silica sand in the "Project X" can be a raw material for the industry of borosilicate glass, flat or container glass, insulating fiber, abrasive sand, refractory sand and brick, foundry sand, and silica sand filter. “Project X” silica sand needs special treatment in the form of washing and separating a number of compounds so that it can meet the criteria for more advance products such as low iron silica sand, optical and ophthalmic glass, crystal glass, and chemical sand.

4. Conclusions

Based on the study conducted on the "Project", the conclusions are as follows:

1. The study area which is an area that has not been affected by anthropogenic activities has been proven to have silica sand deposits
2. Silica sand in the study area in its natural condition generally meets the product specification requirements as molding sand and white silica
3. Additional treatment is required for silica sand in the study area to meet low iron silica specifications, including washing and separating Fe to increase the proportion of SiO_2 content while reducing Fe_2O_3 content

Acknowledgments
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