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# BEGIN REPORT

**MINERAL AND GROUNDWATER SURVEY  
(PHASE II)**



**BERBERA SULPHUR DEPOSITS**

**SOMALIA**

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**UNITED NATIONS  
DEVELOPMENT PROGRAMME**

SOMALIA

MINERAL AND GROUNDWATER SURVEY (PHASE II)

BERBERA SULPHUR DEPOSITS

Technical report

Prepared for the Government of the Somali  
Democratic Republic by the United Nations,  
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United Nations Development Programme



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## INTRODUCTION

The project, Mineral and Groundwater Survey (Phase II),<sup>a</sup> included as one of its secondary targets an examination by shallow drilling, pitting and trenching of a selected area near Berbera known to contain deposits of sulphur, all aiming at the preparation of a follow-up programme to be carried out by the Geological Survey Department of Somalia. The Plan of Operation (as amended 14 June 1971) called for exploratory work at the Berbera sulphur deposits to commence soon after 1 November 1969 and to be completed by the first quarter of 1971.

This report provides a record of that examination. It concludes that because there are fewer than 1,000 tons of sulphur scattered over nine sites, and occurring in concentrations averaging only 3.4 per cent sulphur, no further exploration or follow-up is recommended in the Berbera area.



## BACKGROUND

The sulphur occurrence is situated immediately to the west of the town and deep-water sea port of Berbera (approximately  $45^{\circ}$  E.,  $10^{\circ}$  N.) where it covers an area of 1 sq. km. Two minor outcrops of sulphur-bearing rocks were found within the town itself, but examination showed them to be too small to have any practical importance.

Sulphur mineralization in the Berbera district was first examined by the Colonial Development Corporation in 1952. Geologists of the Somaliland Protectorate Geological Survey reported that the occurrence possessed only about 100 tons of impure material spread over an area of 100 yards square (Pallister, 1957). The mineralization was believed to "have originated from an underlying fault related to the extrusion of the Aden volcanics" (Hunt, 1960).

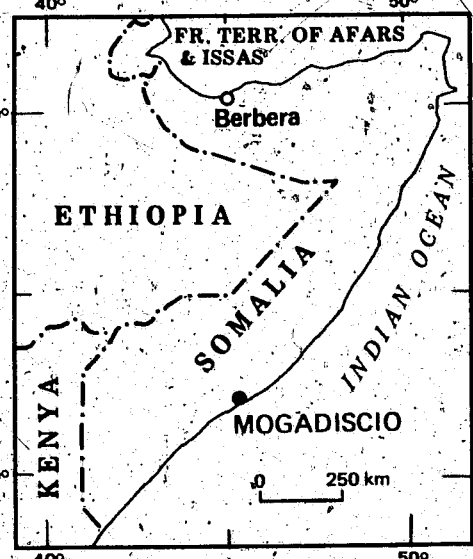
In the fall of 1969 the project undertook a re-examination of the occurrence, having in mind the proximity of the area to the newly constructed port of Berbera. In addition to the one mineralized site known in colonial times, eight new localities of similar, or somewhat smaller, lateral extent were found, and these were prospected by means of trenching, pitting and auger-drilling with subsequent sampling of sulphur-bearing material. The location of these sites in relation to Berbera is shown in Figure 1.

## GENERAL GEOLOGY OF THE BERBERA AREA

The sulphur mineralization is confined to a formation of coralline rag and coquina limestone which forms the base of a raised beach, eight metres wide and covered with Recent loose or poorly cemented sand. No



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BERBERA SULPHUR DEPOSITS  
LOCATION OF SITES 1 to 9



GULF OF ADEN

BERBERA

Hospital

Police Station

Mosque

Main line

SHELL

Camp

AIRPORT

0 200 400 600 metres

To Buuro

To Hargeisa

- 2 Ore body, site number
- 500 Prospecting line
- ~ Geological boundary
- ▨ Town
- Main road
- ↗ Tug, with direction of flow
- - - Track, motorable
- ⬮ Coral limestone, outcrop

N

FIGURE 1

earlier sediments are known in the immediate vicinity of the occurrence, although low hills composed of similar reef limestones and referred to as Pleistocene occur about 1 km to the south. Temporary stream channels are incised in the sulphur-bearing sediments to depths ranging from .5 to 3 metres. They are filled with poorly sorted sand and gravel, showing a poorly defined current bedding, and containing cobbles up to 30 cm in diameter. Both the mineralized rocks and the stream-bed alluvium are covered by a continuous mantle of loose sand of a probable mixed alluvial-diluvial origin, interrupted only over slightly elevated outcrops of hard sulphur-bearing rocks. Three of the nine known sulphur occurrences are located to the north of the escarpment bordering the raised beach on its northern, seaward side. They fall within the limits of the low beach and the sediments enclosing the mineralization are arkosic sand and blue gypseous clay.

#### EXPLORATION AT SITES 1-9

All the known sites, except No. 9 which was previously examined under the colonial administration, were prospected by means of trenching, pitting and shallow auger-drilling. Figure 2, a plan of the exploratory work done at site 8, shows the typical geological and dimensional aspects of the sulphur occurrences.

In all, 622 line metres of trenches were driven, distributed between the mineralized sites as described below.







##### Site 1. Four trenches totalling 154 line metres:

Trench 1-1 and south-east extremity of trench 1-3 reach a depth of 1.5 metres while farther to the north-west, that is towards the sea, the trenches are 0.5 metre deep owing to the shallow-lying water-table.

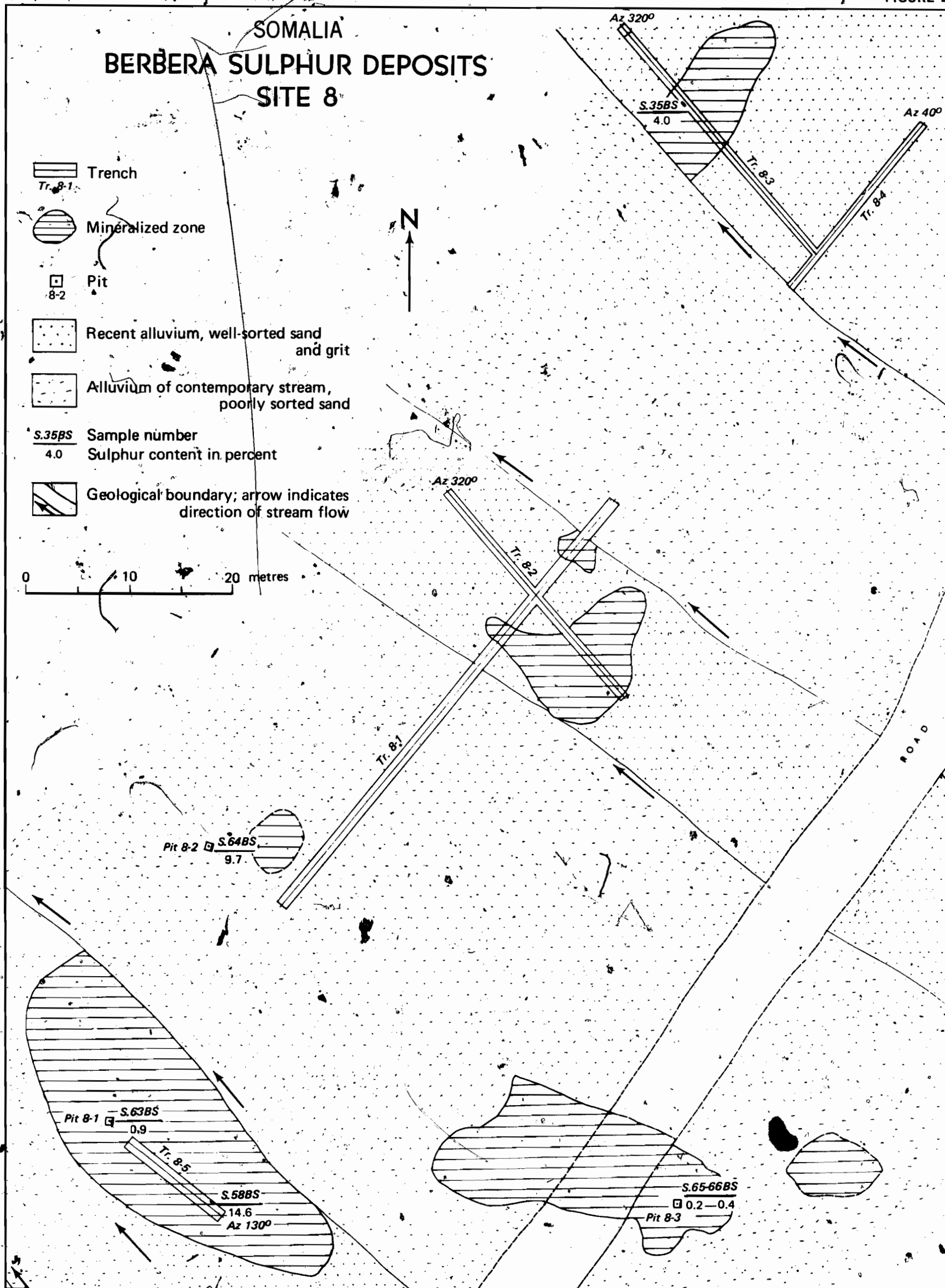
# SOMALIA

## BERBERA SULPHUR DEPOSITS

### SITE 8

-  Trench  
 Tr. 8-1
-  Mineralized zone
-  Pit  
 8-2
-  Recent alluvium, well-sorted sand and grit
-  Alluvium of contemporary stream, poorly sorted sand
- S.35BS  
 4.0  
 Sample number  
 Sulphur content in percent
-  Geological boundary; arrow indicates direction of stream flow

0 10 20 metres



Site 2. Five trenches making a total of 67 line metres:

The depth of the trenches is generally 1 metre, but somewhat deeper over a few short intervals,

Site 3. Two trenches making a total of 23 line metres.

Site 4. Four trenches totalling 46 line metres.

Sites 5, 6, 7 and 7a. These are very closely situated, and at first they were believed to be outcrops of a single deposit. They were plotted together and regarded as a single prospecting area. In all, 10 trenches, making a total of 197 line metres, have been driven. The trenches are about 1 metre deep on an average, ranging from 0.4 metre to 1.5 metres although in certain places, particularly near the boundary of an ore body, they are 2.5 to 3.0 metres. Attempts to drive similar deep pits in the centre of individual ore bodies failed owing to the extreme hardness of the rocks and the lack of explosives.

In addition, three pits were sunk on site 7 for sampling purposes and 2 pits north of site 5 for the purpose of following the mineralization northwards.

Site 7. This site appeared to be the most promising, and it was therefore covered by a fairly dense grid of auger drill-holes. They cut mineralized rocks to depths from the surface of 3 to 4 metres. Some holes intercepted thin zones of poorly mineralized rocks at greater depths.

Site 8. Occurrences of sulphur-bearing sediments were found in the course of the prospecting work, and subsequently five trenches, totalling 135 line metres, were driven with a view to tracing mineralization between the outcrops (Figure 2). Unfortunately, the trenches were not completed

for want of time and have given no conclusive result. However, it appears that the ore bodies are not connected, and that the total area of mineralization is rather limited.

Sampling. All mineralized rocks in the prospected area were systematically sampled. Those cut by trenches and pits were sampled by means of vertical channels down their walls. The cross-section of the channels measured 10 x 3 cm; the length depended on the thickness of the lithologic unit sampled, but none exceeded 1 metre.

Material from the auger-drillholes was also collected, generally one sample from each hole, and, where possible, 1.5-metre intervals of the holes were sampled separately. Because it was soon evident that any exploitation of the sulphur of Berbera would involve development of all sites, the sampling records and results are given in terms of all nine sites as a whole rather than site by site.

#### HOST ROCK

The sulphur mineralization in the Berbera area is confined to various rock types, including limestones, bedded limestone-gypsiferous bands, grey raised-beach sandstones and later sandy accumulations. Limestones include a coquina type, coralline rag and a medium to fine-grained massive variety made up of grained calcite with an admixture of detrital, rounded, quartz and feldspar grains which can be more appropriately termed calcareous sandstone. The reef limestone consists of coral fragments with interstices filled with calcareous sand. Coquina limestone made up of shell fragments occurs as thin lenticular interlayers. Thin layers of fine-banded gypsum intercalated with fine-grained limestone occur sporadically on prospecting site 9.

The raised beach sandstone is of compact massive type, composed of well-rounded, sorted quartz and feldspar grains with a considerable admixture of magnetite. Zircon and monazite were noted in accessory quantities.

Alluvium of Recent age forms linear bands along stream-channels. It consists of loose and poorly sorted, in places obliquely bedded, sand, enclosing thin interlayers of grit and pebbles and individual cobbles and boulders of igneous and metamorphic rocks which are scattered throughout the succession. The entire assemblage of sediments is capped by a more or less continuous, thin mantle of loose Recent sand, formed by the action of a water run-off that does not follow well-defined channels but, owing to the generally flat topography, spreads more or less uniformly over the area. On the seaward flank of the prospecting area dark bluish-grey clay and loam predominate.

#### MORPHOLOGY OF ORE BODIES

The mineralized rocks in the prospecting area usually make isolated deposits isometric or oval in plan. In many cases, the shape of an ore body is outlined on the surface by a band of dark grey to black material .1 to .5 metres wide. Such bands are interrupted only by Recent stream accumulations and by wind-blown sand. The smallest outcrops are round and measure a few metres in diameter, whereas those of prospecting sites 1 and 7 are oval with their short axes ranging from 20 to 40 metres and the long ones reaching as much as 50 metres. The band of black material is altogether absent on site 8, which is underlain by coralline rag and massive gypsum.



In vertical section, the shapes of the mineralized zones are irregular, some being flat and horizontal, vertical or even steeply dipping and others fingering into the surrounding rock. In general the ore-bodies look like irregular pods, while near the surface they show more definite dome-like outlines. In many cases the trenches did not reach the base of the ore-bodies although they are more than 3 metres deep: at this point the rock is so hard at depth that the trenches and pits could not be deepened without blasting. Judging by the results of auger-drilling, few of the ore-bodies are as thick as 4 metres and it is most probable that the hardest rocks occur at the base. Drillholes also cut thin (30-50 cm) lenticular zones of sulphur-bearing rock at depths of 5 and 6 metres, but these are small and of little value. Such a mineralized zone, however, might be only about 1 metre thick, even less in some sections. Thus the lower limit of the sulphur-bearing zones is irregular. However, the average thickness of the ore-bodies throughout the area can be estimated as 2 metres.

#### STRUCTURE AND COMPOSITION OF ORE BODIES

All the ore-bodies examined, except Site 9, show a marked similarity in their substantial composition and internal structure. As mentioned above, in the general description of the area, their outer zone consists of black, massive, rather hard rock which was identified as bitumen-cemented arkose sandstone. The bitumen forms coatings on rounded detrital grains of quartz and feldspar and fills the interstices. The thickness of the bituminous zone ranges from a few millimetres to 10 cm. In the latter case the zone consists of a series of thin bands, 2 mm to 5 mm

thick, of black, highly bituminous, material separated by 3 to 10-mm intervals of a less intensely coloured sand. On the surface the band reaches a width of up to 0.5 metres, and in some cases minor amounts of bitumen are present throughout giving the sand a grey colour.

Further inwards, the bituminous band is followed by a calcareous zone consisting of white, fine-grained calcite. In many cases this zone shows a fine-banded structure expressed by thick zones of pale-yellow to reddish-yellow sandstone with only a minor admixture of calcite. The detrital component of the rock is essentially quartz with subordinate amounts of feldspar grains and rare feldspar pebbles.

The banded structure of the calcareous zone is thus the result of replacement of primary calcareous zones. Disseminated grains are present of a soluble mineral of salty-sour taste, provisionally identified as thenardite. This absorbs atmospheric moisture, giving rise to formation of an acid, presumably sulphuric. The calcareous zone ranges in thickness from 20 cm to 2 metres but throughout an individual ore-body it is continuous and uniform in thickness.

This zone passes gradually into a contiguous zone containing a high proportion of thenardite which lends the rock an orange colour. It is actually this rock that gives rise to the formation of sulphuric acid. The thenardite zone is not uniform in thickness, even within the same ore-body, nor continuous, and it consists of a series of bands, lenses and irregularly shaped aggregates ranging in diameter from 10 cm to 2 metres. The detrital component of this rock consists of quartz and feldspar, which are common to every ore-body.

The mineralized or sulphur zone is confined to the inner part of each succession of banded zones described above. It consists of calcareous sandstone carrying more or less uniform poor impregnation of coarse (2-4 mm) grains of native sulphur. Against this background of poor mineralization, there occur certain irregular blocks of similar sandstone rather densely impregnated with sulphur. Zones of comparatively rich mineralization occur in which only a few detrital grains and some calcite and gypsum are to be found. Irregularly shaped segregations of the orange-coloured soluble mineral thenardite are present in the inner mineralized zone of ore-bodies.

The structure of the mineralized sulphur zone is massive. In places, poorly banded structure is discernible owing to certain strata being mineralized. As a whole, the mineralization is uneven, and comparatively rich zones alternate with poorly mineralized or barren ones. Prospecting site 9, reported above to be somewhat different from the other, is actually composed of corraline rag with minor interlayers of coquina limestone. Both varieties are cemented with a calcareous material and the sulphur mineralization is a replacement type after the carbonaceous material. Gypseous bands 10 to 30 cm thick are interbedded in the formation. The mineralization is rather poor and uneven.

#### Sampling results

The average (arithmetic) sulphur content, calculated from the results of 71 analyses, was 3.4 per cent S, the absolute values ranging from .2 per cent S to 53 per cent S (see Annex). Only seven samples exceeded the value of 10 per cent, being absolutely anomalous as compared

to the bulk of the samples, and keeping in mind that most of these channel samples are of a similar length one can safely state that the proportion of high-grade ore is very low and that the general tenor of the sulphur-bearing ore is also low.

As far as the tonnage of the sulphur-bearing rock is concerned the following figures, showing the extent of the mineralized sites in square metres, are relevant:

<u>Site</u>	<u>Area</u>
1	1,824
2	150
3	56
4	212
5	244
6	48
7	1,352
8	900
9	2,324
Total	7,110 square metres

The average thickness, calculated on the basis of all trenches and drillholes, is approximately 2 metres. Thus the total tonnage of the sulphur-bearing rock amounts to  $7,110 \times 2 = 14,220$  cu. metres, which at specific gravity of about 2 and sulphur content of 3.4 per cent, will make:

$$\frac{14,220 \times 2 \times 3.4}{100} = 967 \text{ tons of sulphur}$$

### Conclusions

The occurrence is of no commercial value and no further exploration is recommended in the Berbera area. However, keeping in mind that the geological conditions similar to those at Berbera prevail over a long stretch of the Gulf of Aden coast, attention should be paid by the Geological Department to any findings of native sulphur in the area. Other sulphur deposits may be found along the Gulf of Aden.

### Bibliography

- Hunt, John A. (1960). Berbera and Burao District. Report on the Geology of the Berbera Sheikh area.
- Pallister, J. (1957). Mineral resources of Somaliland Protectorate.

**BEGIN**

**ANNEX**

Annex

CHEMICAL ANALYSES OF BERBERA SULPHUR SAMPLES

Chemical assay performed by Robertson Research Mineral Technology  
Limited, North Wales, United Kingdom.

<u>Sample</u>	<u>Sulphur</u> <u>(per cent)</u>	<u>Sample</u>	<u>Sulphur</u> <u>(per cent)</u>	<u>Sample</u>	<u>Sulphur</u> <u>(per cent)</u>
1	0.5	25	0.4	48	0.2
2	0.6	26	33.0	49	0.6
3	0.2	27	25.0	50	0.2
4	0.2	28	0.7	51	0.2
5	0.2	29	0.3	52	0.3
6	52.0	30	0.2	53	6.5
7	1.1	31	0.7	54	0.2
8	0.5	32	0.2	55	0.6
9	53.0	33	0.2	56	0.2
10	1.3	34	0.3	57	0.2
11	0.2	35	4.0	58	14.6
13	0.5	36	0.6	59	0.2
14	0.2	37	0.2	60	0.2
15	0.4	38	0.2	61	26.0
16	0.5	39	0.4	62	2.3
17	2.4	40	8.4	63	0.9
18	0.4	41	0.4	64	9.7
19	31.0	42	0.3	65	0.2
20	0.5	43	0.4	66	0.4
21	0.2	44	3.9	67	0.2
22	0.4	45	0.2	68	0.4
23	0.3	46	3.4	69	0.2
24	0.3	47	0.3	70	0.3
				71	1.0

**END**

**ANNEX**







**END  
REPORT**