

Heavy Mineral Sands in Vietnam 2003

Ilmenite potential in Vietnam

Henrik Stendal



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Abstract	3
Introduction	4
Itinerary schedule	4
Administrative business	6
DGMV	6
Sumitomo Corporation / Mitraco Co.	6
Local Industrial Departments.....	7
Marine and Mineral Resources Centre.....	7
Physiographic conditions	9
Geology of the Ham Tan area	10
Sampling procedure	11
Fieldwork.....	12
Field areas	12
Analytical results	20
Special assignment results.....	21
Stockpile ilmenite	26
XRF of ilmenite.....	26
Conclusions	28
Acknowledgement	29
References	30
Appendix	31

Abstract

The fieldwork in 2003 was carried out in the Ham Tan area in southern Vietnam. Altogether 35 samples of raw sand samples were collected. The heavy mineral content in the sands varies a lot within the areas. Most of the heavy mineral occurrences occur in aeolian sand dunes. The most promising area for heavy mineral resources looks like to be the area between Chum Gang and Tan Thang. These areas have the largest potential in tonnage and are not planned for other purposes such as industrialisation or urbanisation.

A special assignment was to collect samples of the ilmenite concentrate from the Ky Khang deposit, Ha Tinh province. The stockpile was a 15,000 tonne ilmenite heap where 10 samples were taken. XRF results of the ilmenite from the stockpile are given in this document. In addition, a CCSEM analysis is given of the raw sand, which is the basis for the ilmenite concentrate. This CCSEM analysis of the raw sample from Cam Xuyen has high-grade of TiO_2 with more than 60% (see figure below).

During the meetings with different organisations in Vietnam it turned out that there is still areas with high-grade ilmenite in Vietnam e.g. the Hué region. The Marine and Mineral Resources Centre gave us this information about the new high-grade ilmenite placer deposits. The Centre will try to help to get this information verified. This Hué region has not been visited in our joint program but will be the next target for investigations.



Figure 1. *The field sampling party – from left the driver Mr. Tinh, Deputy Director Mr. Hop, and Senior Geologist Mr. Thien.*

Introduction

The joint venture heavy mineral sampling programme between the Department of Geology and Minerals of Vietnam (DGMV), the Geological Survey of Denmark and Greenland (GEUS) and DuPont continued the work from 2002 (Stendal 2003) in 2003. The latter sampling tour (Fig. 1) and the results of the black sands is reported below.

The fieldwork was carried out in the period from May 5 to May 22nd including travel time. The main focus of the field-sampling programme was the Ham Tan area, which covers parts of the provinces Binh Thuan and Vung Tau – Ba Ria in southern Vietnam (Figs. 2 and 3). A special assignment was to collect samples of the ilmenite concentrate from the Ky Khang deposit, Ha Tinh province. The shipment for Dupont is a 15,000 tonnes ilmenite stockpile at the port of Vung Ang. The travelling distance altogether during fieldwork was 4,365 km.

Itinerary schedule

May 5 – departure Denmark

May 6 – arrival Hanoi, Vietnam via a transit in Bangkok. Planning of next day

May 7 – meetings at DGMV and planning of fieldtrip. Meeting with Sumitomo Corporation

May 8 – fieldtrip starts – travel to Hué – 650 km

May 9 – travel to Nha Trang – 600 km

May 10 – travel to Phan Thiet and meeting at the local Industrial Department Office – 250 km

May 11 – fieldwork in the Ham Tan area – 120 km

May 12 – fieldwork in the Ham Tan area – 202 km

May 13 – fieldwork in the Mui Né area and travel to Vung Tau. Meeting at the local Industrial Department office – 236 km

May 14 – fieldwork in the Long Hai and Vung Tau areas and travel to Ho Chi Minh City (Saigon) – 260 km

May 15 – travel Ho Chi Minh City - Dalat – 345 km

May 16 – travel Dalat – Quy Nhon – 405 km

May 17 – travel Quy Nhon – Dong Ha – 539 km

May 18 – travel Dong Ha – Thien Cam and meeting with Mitraco Hatinh – 318 km

May 19 – together with people from Mitraco Hatinh for collecting ilmenite concentrates samples at the warehouse of Vung Ang Port and at the Cam Xuyen Separation Plant. Travel to Hanoi – 510 km

May 20 – meetings at DGMV and budget accounting

May 21 – meeting at the Marine Geology and Mineral Resources Centre and departure from Hanoi to Bangkok

May 22 – Bangkok to Denmark

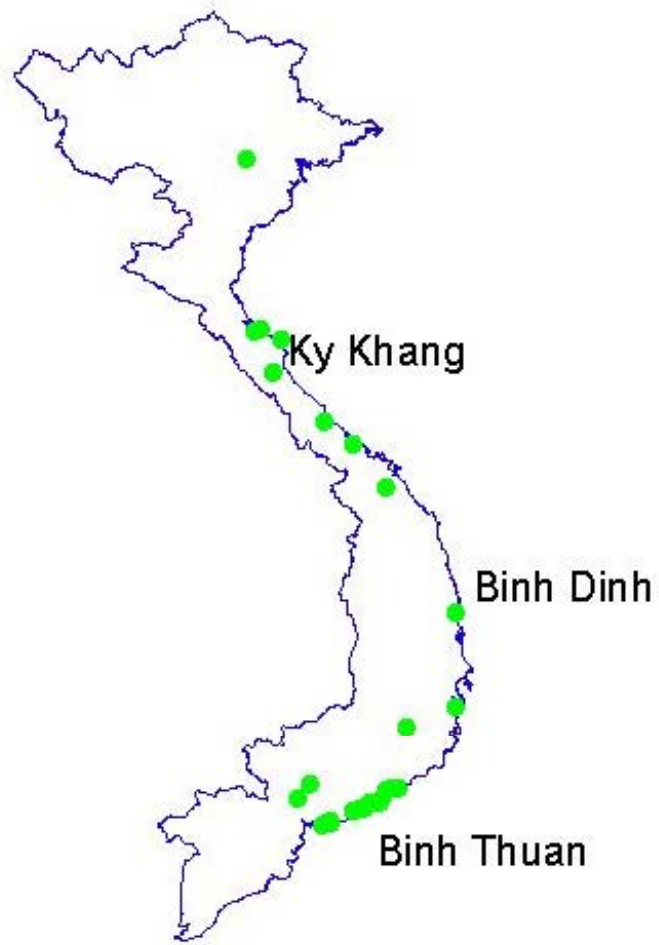


Figure 2. *Main sampling area in Bin Thuan 2003 in southern Vietnam*

Administrative business

On May 6 I was picked up by Vice Director of 'International Cooperation Division' Mr. Hop and Ms. Bui Thi Huyen, interpreter from the 'International Cooperation Division' in the Hanoi International Airport. They took me to the ATS Hotel, which is placed only 5 minutes walk from the Department of Geology and Minerals of Vietnam (DGMV). At the hotel the programme for the next day and the coming field trip was briefly discussed. We also handled the formalities and budget for the fieldwork.

DGMV

A formal morning meeting at DGMV concerned a presentation of the heavy mineral project in Vietnam by HSt. The project is carried out as a joint project between DGMV, GEUS and Dupont (Stendal 2003). The formal meeting had representatives from the board of directors and interested geologists from DGMV. Twelve people attended the meeting and among those were:

- Deputy Director General, DGMV, Dr. Nguyen Thanh Van,
- Director for Administration, DGMV, Mr. Nguyen Van Quyen,
- Director, Marine Geology and Mineral Resources Centre (MGMC), Dr. Dao Manh Tien,
- Deputy Director of Geological Section, DGMV, Dr. Nguyen Van Quy,
- Vice Director of International Cooperation Division, DGMV, Mr. Hop
- Ms. Bui Thi Huyen of International Cooperation Division, DGMV, interpreter and she also acted as interpreter at the meeting.

After the formal meeting the coming fieldwork were planned with the Director Ms. Nguyen Thi Dzung, the Vice Director Mr. Hop and the interpreter Ms. Bui Thi Huyen.

After the fieldwork another meeting was held at DGMV concerning accounting and reporting on the fieldwork for the administration at DGMV.

Sumitomo Corporation / Mitraco Co.

The same day I left Denmark I was requested from Dupont to take samples from the ilmenite that is being stockpiled for Dupont's upcoming shipment in early July. There is about 15,000 tonnes already produced and stockpiled. I got e-mail from Norman B. Shurak, Dupont with a contact address in Hanoi. After a phone contact to manager Ms. Pham Thi An Ninh, Sumitomo Corporation we arranged a meeting at the company's residence in Hanoi at 2 p.m. The Sumitomo Corporation is distributor for Mitraco Co. We (HSt, Ms. Huyen and Mr. Hop) had the meeting together with the manager Ms. Pham Thi An Ninh and assistant manager Ms. Nguyen Thuy Ha. The director himself was in Ha Tinh. The managers thought it was OK to take the samples but we got the agreement that we should phone before leaving the Ham Tan area and pick up the samples on May 18 or 19 on our way

back to Hanoi. The stockpile is placed in a warehouse at Vung Ang Port. The purpose with the samples (10 samples) was to check if the piles of ilmenite are homogeneous concerning the TiO₂ content, impurities and grain size.

On May 18 we met the Director General of Mitraco Co. Mr. Vo Kim Cu and again on May 19 after we had sampled our ilmenite samples from the stockpile in Vung Ang Port and at the separation plant in Cam Xuyen. Director General Vo Kim Cu is head of Viet Nam Titanium Association and Hatinh Minerals and Trading Corporation (Mitraco Hatinh). At the sampling sites the Technical Manager Mr. Bui Van Bang accompanied us.

Local Industrial Departments

The Binh Thuan Industrial Department in Phan Thiet was visited and the Chief of Mineral Resources Management Service, Mr. Nguyen Van Tam told us about the heavy minerals in the region. The total heavy mineral ore in the area comprise 100 km² and the tonnage is estimated to be between 5-10 mill. Three deposits have 700,000 tonnes of ilmenite. The office provided us with maps showing the location of the heavy mineral deposits. In addition, Mr. Do Xuan Lam accompanied us during the fieldwork.

In Vung Tau the Deputy Director Mr. Ha from the Mineral Division of Industrial Department of Ba Ria – Vung Tau Province received us. During the fieldwork in that region Mr. Pham Huynh Khang guided us.

Marine and Mineral Resources Centre

The future name for this Centre will be Marine Geological Division. The visit to the Centre was an acceptance of an invitation from the Director Dr. Dao Manh Tien, who thought that we had some common interests. Deputy Director Mr. Vu Truong Son welcomed us. He introduced us to the Centre and their activities. The main activity for the Centre within the last few years has been the completion of the investigation and reporting of the 'Geology and mineral resources of the shallow offshore area of Vietnam at 1:5000,000 scale (0-30 m water depth)'. The maps were still in progress but some maps were completed. The maps exist both as hard copy and as digital maps made in Arc/MapInfo. Among the result Quaternary and superficial sediments have been subdivided. The thickness of the Quaternary sediments, the extent of fault systems has been determined based on shallow seismic data. Mineral resources such as placers of ilmenite, zircon and common sands are located. The prospective zoning of these minerals is still preliminary, corresponding to small-scale survey level. The shallow-water depth studies also give information on environment matters, stability of the shoreline and evaluation of the impact of economic activities on the environment. In local areas isobathic maps with interval of one-two m and topographic features in the shallow offshore area are produced, which are of high utility for various economic and basic survey sectors.

The Centre had also information about new high-grade ilmenite placer deposits in the Hué area. The Centre will try to help to get this information verified. The Centre does joint projects with companies and the Provinces of Vietnam.

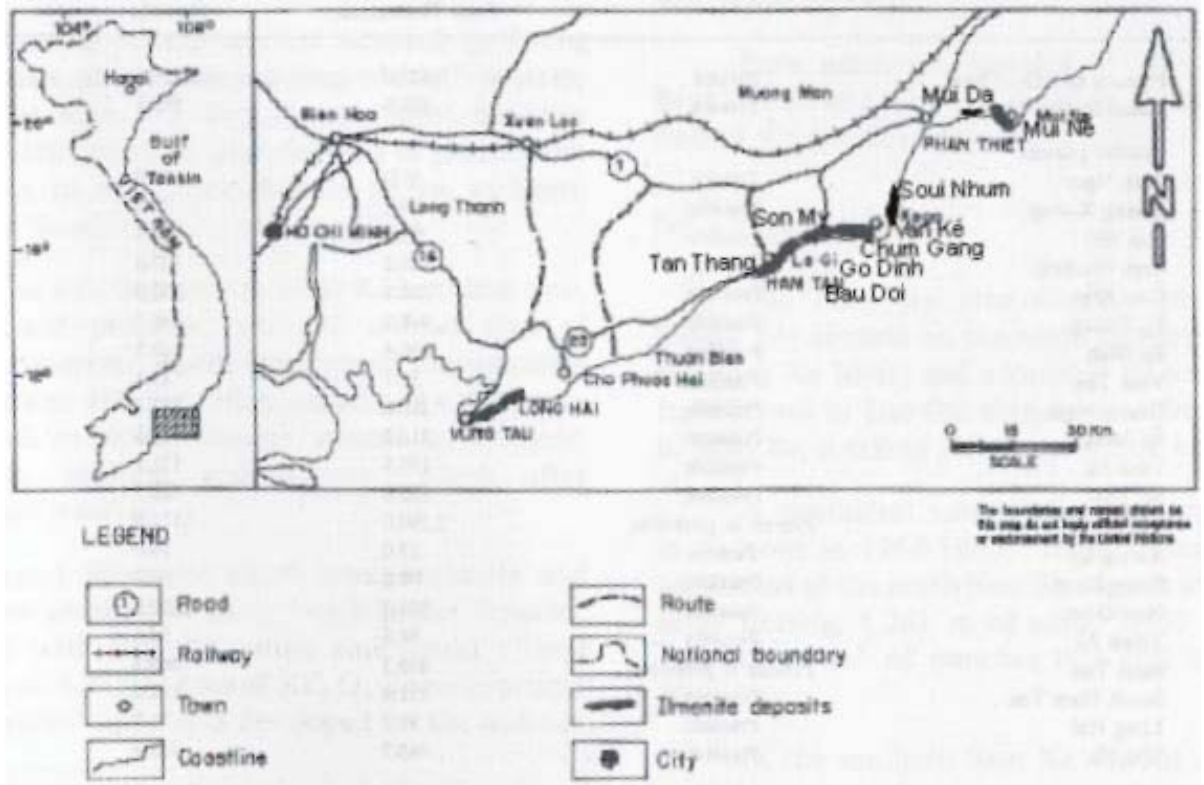


Figure 3. Bin Thuan region and the sampling localities from Mui Né in East to Vung Tau in West.

Physiographic conditions

Access to the sampling sites is in most cases easy but on some sites walking up to a few kilometres is necessary. Highway No. 1 pass the region and all bigger roads have asphalt and smaller roads are stone paved. Railway connection occurs close to Phan Thiet. Port facilities are present in Vung Tau. The climate is hot and humid all the year around with many sun days and the rainy season from May to November. The average temperature all year is around 27°C and the precipitation varies from 1200 to 2000 mm/year.



Figure 4. *Typical sand dunes in the Soui Nhum area.*

Geology of the Ham Tan area

The coastal accumulative plain has a width of 10 to over 20 km, formed by Holocene marine or fluvio-marine sediments. The seashore is in many places characterised by opened gulfs separated by small mountains. The strip of coastal terraces formed by fluvio-marine deposits is 10-50 m in heights. Behind these terraces red sand raising up to some hundreds metres. Along the coast zone discontinuous bands of sand dunes occur ranging 5-20 m in height in comparison with the adjacent relief. The sand is well-sorted and well-rounded, yellowish-grey coloured. The grain size is fine to medium-grained sand with the main composition of quartz (95-98%) with varying amounts of heavy minerals. Between the fluvio-marine sediments and the sand dunes marine-marshy lowland occur. This is an area of salt-marshy forest lying in the estuarine and coastal zones (mangrove zone). The hinterland behind the coastal zone consists of Lower-Middle Jurassic sediments and Upper Jurassic-Cretaceous volcanogenic formations, covered by Cenozoic basalts and sedimentary formations.

The tectonic evolution in the Pliocene-Quaternary period is stable except for magmatic hot spots. During Middle and Late Pleistocene the alkaline basalt effusion appeared in an arched uplift. In the piedmont plains and valleys, and the coastal zone the depositional accumulation took place with unconsolidated sediments of marine-aeolian facies. In the hilly zones the processes of weathering, erosion and abrasion occurred.

The ilmenite resources within the Phan Thiet geological map (Thang 1999b) the ilmenite occurrences are described as marine placer deposits. The ore body stretches from 1,500 to 15,700 m, with a width of 150 – 1,800 m, and a thickness of 1 – 3.5 m, in places up to 10 m. The reserves of ilmenite is approximately 500,000 tonnes of ilmenite and 80,000 tonnes of zircon. In the southern Ham Tan area and Long Hai the ilmenite occurrences is described as littoral placer type. The reserves in these latter areas are nearly 200,000 tonnes of ilmenite and 33,000 tonnes of zircon. The fieldwork revealed that the ilmenite occurrences all are interpreted as aeolian dune deposits (Fig. 4).

For further reading of the geology to the area the descriptions to the 1:200.000 scale geology and mineral resources map of Vietnam is recommended. The descriptions are published in 1999 and cover the Phan Thiet sheet (C-49-VII) Gia Ray – Ba Ria sheet (C-48-XII & C-48-XVIII) – see Thang 1999a & 1999b.

Sampling procedure

A hand-auger (Fig. 5) was used for sampling in the beginning but it was not a great success of different reasons. Firstly, it was very hard to drill into the dunes and secondly in most cases the sample material did not stay in the tube. The hand-auger was 2 m in length and had a 30-cm long tube, which was 5 cm in diameter. Most of the samples are taken as one to two m profiles after digging into the dune or where steep section of the dune showed cross bedding. The sample is scraped along the wall in the hole/section with a small stainless shovel. The size of the sample is between 500-1000 g. All samples are representative for the site as described in the sample description. The latitude and longitude coordinates are given in decimal degrees (Table 1).



Figure 5. *The auger in use on a sand dune, Soui Nhum deposit.*

In the Ham Tan region 35 HM samples were collected during the field campaign. For the special assignment concerning Ky Khang deposit and its stockpile (10 samples) and new sample from the Camson deposit. The HM sands from Camson are mixed with the Ky

Khang sands in the processing plant and one sample of the ilmenite concentrate were taken.

In the laboratory the raw sand samples are poured into heavy liquid to get the heavy minerals (HM) separated. A split of the HM separate is taken for the CCSEM analysis.

Fieldwork

The travelling team met at ATS Hotel 6.15 a.m. (May 8) in a blue four-wheel drive Toyota Landcruiser. The team comprises the Vice Director Mr. Hop, Senior Geologist and interpreter Mr. Thien, and the same driver as last year Mr. Tinh. We departed at 6.45 a.m. heading south out of Hanoi. We had a short stop in Vinh City and picked-up the hand augers to be used during the fieldwork. We passed Ha Tinh and 50 km south of Ha Tinh the stockpiles of ilmenite for shipping to USA is placed at Vung Ang Port in a warehouse. We passed the Demilitarised Zone (DMZ) at 17⁰N and ended up in Hue City at Le Loi Hotel six o'clock p.m. On May 9 we drove the whole day and reached Nha Trang eight o'clock in the evening altogether 600 km. We stayed overnight in guestrooms at the 'Central Vietnam Division of Hydrology and Engineering Geology' where the Director Mr. Vu Ngoc Tram gave us great hospitality. We left Nha Trang on May 10 heading for Phan Thiet where we arrived at 12.30 p.m. We had a meeting at the office of the Binh Thuan Industrial Department. The Chief of Mineral Resources Management Service Mr. Nguyen Van Tam introduced us to the Ham Tan region. The area contains 5-10 Mt of heavy minerals over 100 km². The area has until now delivered 700.000 tonnes of 90% ilmenite. The wish for the region was to have a pigment factory, but as a joint venture with foreign investment. We were supplied with copies of maps showing the HM deposits in the area. People of this local office had produced the maps.

In the second field area in the Vung Tau region Mr. Khang from the Mineral Division of the Industrial Department in Vung Tau were our guide in the Long Hai and Vung Tau mineral occurrence areas.

Field areas

Ham Tan region

The distribution of ilmenite deposits in the Ham Tan region and the location in Vietnam is shown in the Figures 1 and 2 (Fig. 2 modified after Loan 1990). The Ham Tan region comprises the following deposits from East to West: Soui Nhum, Van Ké, Chum Gang, Go Dinh, Bau Doi, Son My, and Tan Thang.

Soui Nhum

The aeolian dunes are maximum 10 m high, one kilometre in length and 50-200 m wide. The hand auger has a sampling tube 30-cm in length, which correspond to the sample vol-

ume c. half a litre. The two samples collected had 1-2% heavy minerals in the sand (Table 1).

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
1	10,7732642	108,0178463	VN 01	2000369	Raw sand, dune
2	10,7732642	108,0174976	VN 02	2000370	Raw sand, dune

VN 01 Top of dune, hand auger, and the sample from 2-m depth, 1.0% HM contents.

VN 02 Top of dune, hand auger, and the sample from 2-m depth, 1.7% HM contents.

Van Ké

Aeolian dunes strokes along the coast, less than 10 m high and a few hundreds m wide. The dunes might be deposited on beach sand according to the guides.

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
3	10,7239545	108,0023431	VN 03	2000371	Raw sand, dune
4	10,7243890	108,0036789	VN 04	2000372	Raw sand, dune

VN 03 Middle of dune, hand auger, and the sample is taken in 2-m depth - 0,53% HM.

VN 04 Beach sand (?), base of dune, hand auger, and the sample from 2-m depth - 0,67% HM (Table 1).

Chum Gang

Some parts of this area are already exploited but unexplored large areas still occur. The aeolian dunes are only 1 to 3-m in height and 50 to 100 m in width. The HM content is clearly visible and disseminated. This deposit was also visited last year and the samples V 23 (2000203) and V 24 (2000204) are taken in the same area. The TiO₂ content in ilmenite in these samples was 55%.

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
5	10,7057798	107,9636979	VN 05	2000373	Raw sand, dune
6	10,7068956	107,9603612	VN 06	2000374	Raw sand, dune
7	10,7084996	107,9558014	VN 07	2000375	Raw sand, dune
8	10,7075179	107,9571157	VN 08	2000376	Raw sand, beach

VN 05 Top of aeolian dune, the sample represents one metre profile - 4.4% HM.

VN 06 Middle part of aeolian dune, where the sample represents one metre profile - 6.74% HM.

VN 07 Lower part of aeolian dune, the sample taken with hand auger in 2-m depth - 5.52% HM (Table 1).

VN 08 Beach sample – upper tide zone, the sample represents 0.5-m profile. Relatively high HM content in mm-cm thick bands - 39.16% (Table 1).

Bau Doi A and B

Shallow sand dunes with 2-3 m thick layer rich in heavy minerals in the Bau Doi A deposit (VN 09 - VN 11). The upper 1-2 m of the dune is low in HM content but the lower 2-3 m of the dune is rich in HM. The heavy minerals are sitting in mm-cm thick bands in the cross-bedded dune. In the Bau Doi B deposit (VN 12 - VN 13) the dunes are 20-25 m in height and has the same textures as in Bau Doi B (Figs. 6 and 7).



Figure 6. *Cross-bedded dune with mm-cm thick bands from Bau Doi B.*

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
9	10,7026363	107,8225225	VN 09	2000377	Raw sand, dune
10	10,6994552	107,8162836	VN 10	2000378	Raw sand, dune
11	10,6963921	107,8121101	VN 11	2000379	Raw sand, dune
12	10,6933827	107,8072017	VN 12	2000380	Raw sand, dune
13	10,6893057	107,8055012	VN 13	2000381	Raw sand, dune

VN 09 Middle part of aeolian dune, the sample represents depth of 1 - 1.55 m - 8,49% HM.

VN 10 Lower part of aeolian dune, the sample represents two-metre profile - 7,66% HM.

VN 11 Upper part of aeolian dune, where the sample represents one metre profile - 2,57% HM.

- VN 12 Upper part of aeolian dune, the sample represents one metre profile 5-m below top of dune - 7.32% HM.
- VN 13 Lower part of aeolian dune, the sample represents two-metre profile - 4,43% HM (Table 1).



Figure 7. *Laminae of heavy minerals in sand dune, Bau Doi A.*

Tan Thang

Three different rows of sand dunes all have varying amounts of heavy minerals. Between the sand dunes basins occur with shrimp farming. The dunes are 10-30 m in width and up to several hundreds of m long. The dune longest away from the coast is up to 50 m in width.

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
14	10,5809659	107,5902485	VN 14	2000382	Raw sand, dune
15	10,5857993	107,5929361	VN 15	2000383	Raw sand, dune
16	10,6190479	107,6609140	VN 16	2000384	Raw sand, dune

- VN 14 Upper part of a maximum 5-m high aeolian dune, where the sample represents one metre profile - 5,21% HM.
- VN 15 Upper part of aeolian dune, the sample represents one metre profile. The HM occurs in mm bands averaging 1,86% HM.
- VN 16 Upper part of aeolian dune, where the sample represents one metre profile - 0,63% HM (Table 1).

Son My

At Son My perpendicular to the coastline two profiles were sampled. Two rows of sand dunes occur striking along the coast separated by a lagoon. The dune closest to the sea is 100 wide and up to 10-m in height. The dune away from the coastline is 50 m wide and lower than the sea dune.

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
17	10,6107170	107,6609140	VN 17	2000385	Raw sand, dune
18	10,6093437	107,6615309	VN 18	2000386	Raw sand, dune
19	10,6188923	107,6565313	VN 19	2000387	Raw sand, dune
20	10,6328827	107,7248150	VN 20	2000388	Raw sand, dune
21	10,6313968	107,7230286	VN 21	2000389	Raw sand, beach

- VN 17 Upper part of the coast aeolian dune, where the sample represents one metre profile - 4,71% HM.
- VN 18 Base of the aeolian coast dune, the sample represents 0.5-m profile - 4% HM in mm lamellas.
- VN 19 Middle part of aeolian dune away from the coast, the sample represents 1.5-m profile - 3,35% HM in up to one centimetre thick layers.
- VN 20 Three metres below top of aeolian dune, the sample represents 2-m profile. 12,94% HM occurs in cm-thick layers of black sands.
- VN 21 Beach sand from the upper tide zone, the sample represents 30-cm profile of mm-laminated black sand layers - 27,79% HM (Table 1).

Go Dinh 1 and 2

Some parts of the Go Dinh 1 area has been exploited for heavy minerals but a coast parallel dune and a dune 0,5-2 km from the coast are not exploited. The coast parallel dune is only 2-3 m high, 5-10 m wide and up to 3 km long (sample VN 22). The inland dune is 5-6 m high, 20-30 m wide and several km long along strike (VN 23). Go Dinh 2 consists of an overgrown dune, which varies 5-10 m in height and 50-100 m in width (VN 24).

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
22	10,7198614	107,8813272	VN 22	2000390	Raw sand, dune
23	10,7214707	107,8815096	VN 23	2000391	Raw sand, dune
24	10,7144648	107,8532499	VN 24	2000392	Raw sand, dune

- VN 22 Middle part of aeolian dune, where the sample represents 1.5-m profile - 5.81% HM.
- VN 23 Top of overgrown aeolian dune, where the sample represents one metre profile - 10,99% HM.
- VN 24 Top of overgrown aeolian dune, where the sample represents one metre profile - 4,33% HM (Table 1).

Mui Da

Coast parallel dune up to 20-m in height and 100-150 m wide. The general impression is that the HM content is low. The area is a holiday resort area and under expansion.

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
25	10,9387350	108,1843095	VN 25	2000393	Raw sand, dune
26	10,9433216	108,1899475	VN 26	2000394	Raw sand, dune

- VN 25 Top of aeolian dune, where the sample represents one metre profile - 0,58% HM.
- VN 26 Middle part of aeolian dune and the sample represent 0.5-m profile - 0,35% HM (Table 1).

Mui Né

The Mui Né area develops both industrial and holiday resorts. The dunes in the area are not well defined but cover large areas in the backyard of the town. The dune area is elevated 5-10 m over the town area. The general content of HM is low.

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
27	10,9502310	108,2606345	VN 27	2000395	Raw sand, dune
28	10,9510625	108,2607150	VN 28	2000396	Raw sand, dune
29	10,9433323	108,2925099	VN 29	2000397	Raw sand, dune

- VN 27 Lower part of aeolian dune, where the sample represents one metre profile - 4,86% HM.
- VN 28 Top of aeolian dune, the sample represents 1.5-m profile with 6,05% HM.
- VN 29 Top of partly overgrown aeolian dune, the sample represents one metre profile - 1,69% HM (Table 1).

Long Hai

Mr. Khang from the Mineral Division of the Industrial Department in Vung Tau were our guide in the Long Hai and Vung Tau areas. The potential Long Hai aeolian sand dunes with heavy mineral covers 4 km in length and 200-300 m in width and the height is 2-4 m (Fig. 8). We were given the following figures concerning the HM contents in Long Hai. The potential resources are 72,000 tonnes of ilmenite and 10,500 tonnes of zircon with grades of: Ilmenite 156 kg/m³, zircon 21.9 kg/m³ and rutile 21.9 kg/m³.



Figure 8. Sand dune along the coastline in Long Hai.

The dunes are located very close to the town and within the outbuilding of industrial areas. Some parts of the dune are exploited for sand for construction. The samples represent a profile starting from the coast (VN 30) and going inland.

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
30	10,4039348	107,1914952	VN 30	2000398	Raw sand, dune
31	10,4051364	107,1918386	VN 31	2000399	Raw sand, dune
32	10,4050666	107,1935874	VN 32	2000400	Raw sand, dune
33	10,4061020	107,1951538	VN 33	2000651	Raw sand, dune

- VN 30 Upper part of the aeolian dune and the sample represents 1.5-m profile - 1,10% HM.
- VN 31 Top of partly overgrows aeolian dune, where the sample represents one metre profile - 1,36% HM.
- VN 32 Middle part of aeolian dune but top of dune, the sample represents 2-m profile with 3,14% HM in mm-thick lamellas.
- VN 33 This dune is longest away from the coast. Top of partly overgrown aeolian dune and the sample represents 2-m profile. The profile starts from 1.5-m below the top - 4.59% HM (Table 1).

Vung Tau

The potential of the Vung Tau aeolian sand dunes with heavy mineral covers 8 km in length and 200-300 m in width and the thickness of the heavy mineral bearing layers are 1-3 m. The sand dunes occur in up to three parallel rows. We were given the following figures concerning the HM contents in Vung Tau. The potential resources are lesser than in the Long Hai area with 28,000 tonnes of ilmenite with grades of:

Ilmenite	30-40 kg/m ³
Zircon	1.4-50.6 kg/m ³
Rutile	0.2-9.4 kg/m ³
Leucoxene	1.4-9.4 kg/m ³

The dunes are located very close to especially industrial areas. Some parts of the dune are exploited for sand for construction.

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
34	10,3950298	107,1438324	VN 34	2000652	Raw sand, dune
35	10,3950191	107,1271812	VN 35	2000653	Raw sand, dune

- VN 34 Base of 10-15 m high dune, 100 m wide, where the sample represents one metre profile - 0,76% HM.
- VN 35 Top of overgrown 5-m high aeolian dune, the sample represents 1.5-m profile - 0,50% HM (Table 1).

Analytical results

Table 1. Main result of the CCSEM analyses. See the detailed analyses in Appendix 1.

Lab. #	Field #	% - HM of total	TiO ₂ % excl. Rutile	TiO ₂ % incl. Rutile	% Ilme-nite of total HM	% Rutile of total HM	% Leuco-xene of total HM	% Ti-magnetite of total HM	% Zir-con of total HM	% Gar-net of total HM
2000369	VN 01	1.00								
2000370	VN 02	1.70	56.0	57.6	62.5	3.1	5.4	1.8	7.9	7.9
2000371	VN 03	0.53								
2000372	VN 04	0.67	56.6	58.5	57.9	3.6	6.0	1.9	6.8	2.9
2000373	VN 05	4.40	56.6	59.1	55.4	4.4	8.3	2.8	8.6	6.3
2000374	VN 06	6.74								
2000375	VN 07	5.52	54.4	56.5	58.0	3.7	3.2	4.0	11.7	5.6
2000376	VN 08	39.16	55.3	57.1	51.3	3.0	5.1	4.4	9.8	2.3
2000377	VN 09	8.49	55.3	56.6	59.0	2.3	4.0	4.7	13.5	1.4
2000378	VN 10	7.66								
2000379	VN 11	2.57	56.6	58.8	56.9	3.9	6.2	2.1	9.4	4.4
2000380	VN 12	7.32	55.2	56.3	61.7	2.0	4.2	4.5	9.3	0.3
2000381	VN 13	4.43								
2000382	VN 14	5.21	54.9	58.0	58.7	1.9	4.2	4.2	12.7	1.7
2000383	VN 15	1.86								
2000384	VN 16	0.63								
2000385	VN 17	4.71	54.2	55.1	64.0	1.7	3.0	3.7	8.6	4.0
2000386	VN 18	4.00								
2000387	VN 19	3.35	56.2	57.9	61.6	3.1	2.8	2.0	12.9	3.0
2000388	VN 20	12.94	55.1	56.5	59.3	2.5	5.0	4.9	10.3	2.5
2000389	VN 21	27.79	54.3	54.6	74.2	0.6	2.9	3.4	6.1	1.1
2000390	VN 22	5.81	55.9	57.9	54.0	3.3	6.6	3.9	11.4	5.8
2000391	VN 23	10.99								
2000392	VN 24	4.33	56.5	58.8	55.9	3.8	2.7	2.0	14.7	2.4
2000393	VN 25	0.58								
2000394	VN 26	0.35								
2000395	VN 27	4.86	53.2	55.1	55.1	3.5	5.4	8.3	15.6	1.3
2000396	VN 28	6.05	54.6	56.2						
2000397	VN 29	1.69								
2000398	VN 30	1.10								
2000399	VN 31	1.36								
2000400	VN 32	3.14	56.4	58.0	62.4	3.3	6.0	2.7	15.2	1.7
2000651	VN 33	4.59	56.5	58.7	55.5	4.0	6.8	3.7	6.8	3.6
2000652	VN 34	0.76	61.2	63.7	42.8	4.7	13.1	1.8	7.0	5.5
2000653	VN 35	0.50								
2000665	VN 47	53.74	65.8	73.5	39.6	19.3	12.5	0.6	14.5	0.0

Nearly all the collected samples are taken from aeolian sand dunes, which are striking parallel to the coastline. The total heavy mineral content varies a lot in the raw sand sample but generally the content in the aeolian sand dunes is low with few exceptions (Table 1). In table 1 the heavy mineral contents of ilmenite, rutile, leucoxene, Ti-magnetite, zircon and garnet is also shown together with the average TiO₂ content of all TiO₂ minerals exclusive and inclusive rutile. No other minerals than the mentioned are found interesting in the CCSEM results (Appendix 1).

The sampling area in the southern Vietnam (VN01-VN35) is characterised by uniform distribution of the heavy minerals containing 50-60% ilmenite with a TiO₂ content from 54-57% and 1-3% higher when rutile is included in the calculation (Table 1). Only one sample (VN34) has over 60% TiO₂. This deposit in Vung Tau is rather small and does not have a tonnage potential. The most promising area for heavy mineral resources looks like to be the area between Chum Gang and Tan Thang (Fig. 2). These areas have the largest potential in tonnage and are not planned for other purposes such as industrialisation or urbanisation. The highest TiO₂ content in ilmenite in this area is around 59%, which is found in Chum Gang (VN 05), Bau Doi A (VN11) and Go Dinh 2 (VN24). TiO₂ content around 58% is proven in Van Ké (VN03), Tan Thang (VN14), Son My (VN19) and Go Dinh 1 (VN22). The Mui Da, Mui Né, Vung Tau and Long Hai regions are all in a developing stage such as urbanisation, industrialisation and as tourist resorts.

The most valuable mineral after the ilmenite in the HM samples is zircon, which has considerable amounts from 6-15% of the total HM content. The leucoxene amounts from 3 to 8% except for one sample with 13% (VN34).

Special assignment results

As mentioned in the introduction a special assignment was to collect samples of the ilmenite concentrate from the Ky Khang deposit, Ha Tinh province, which is purchased by Dupont. The shipment for Dupont is a 15,000 tonnes ilmenite stockpile at Vung Ang Port. The stockpile is placed in a warehouse (Fig. 9). The purpose with the samples (10 samples) was to check if the piles of ilmenite are homogeneous concerning the TiO₂ content, impurities and grain size. At Cam Xuyen separation Plant an ilmenite concentrate was collected at the outlet of the ilmenite tube as well (VN 46). In addition, the raw sand from where the ilmenite is separated to Dupont is a mixed sample consisting of sands from two deposits - Ky Khang and Camson (VN 47; Fig. 10). The sample is collected from a stockpile at the separation plant in Cam Xuyen. We do not have a sample from the Camson deposit alone, but have samples from Ky Khang from last year's program.

GPS	LATITUDE	LONGITUDE	Sample #	GEUS #	Type
Vung Ang 36	18,1113160	106,4091700	VN 36-45	2000663	Ilmenite concentrate
Cam Xuyen 37	18,2440371	106,0095316	VN 46	2000664	Ilmenite concentrate
Cam Xuyen 37	18,2440371	106,0095316	VN 47	2000665	Raw sand, mixed

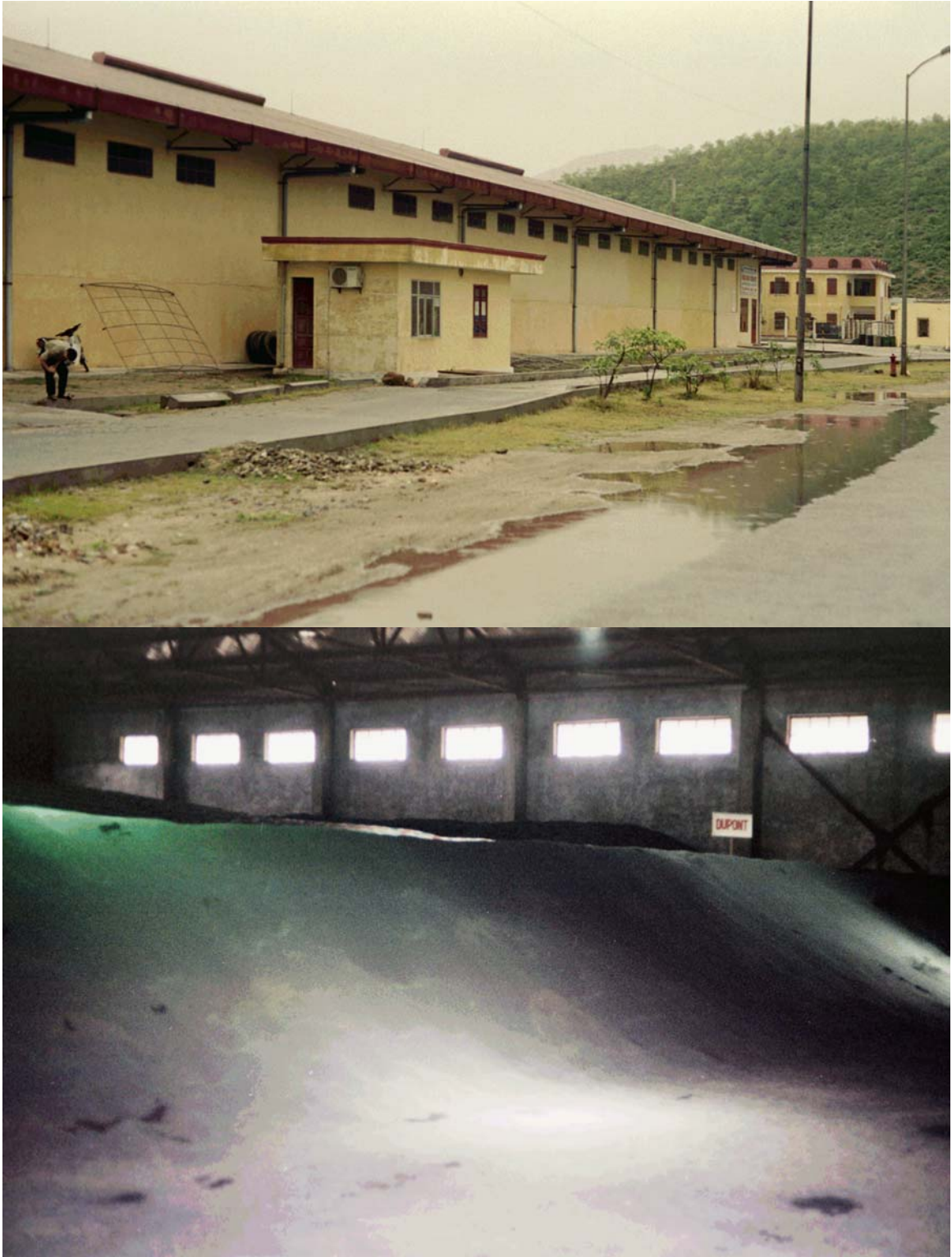


Figure 9. *Warehouse with ilmenite stockpile in Vung Ang.*

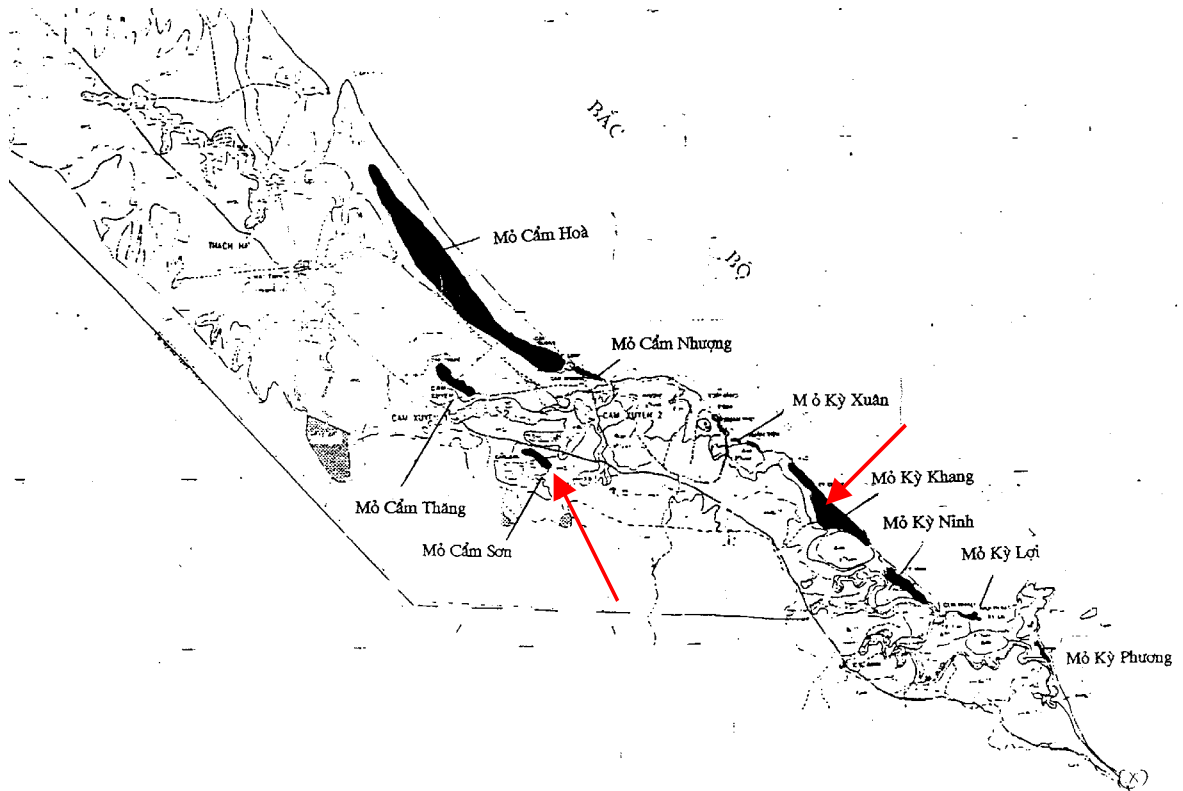


Figure 10. *Distribution of ilmenite deposits in the Ky Khang and Camson (Cám Sơn) area.*

The CCSEM result of the sample from the Camson deposit (VN 47) is given in Tables 1 and 2 and a typical CCSEM image of a heavy mineral sample is shown in Figure 11. The CCSEM data show have high grade of TiO_2 with more than 60% (Fig. 12) and a grain size distribution from 100-200 μm (Figure 13).

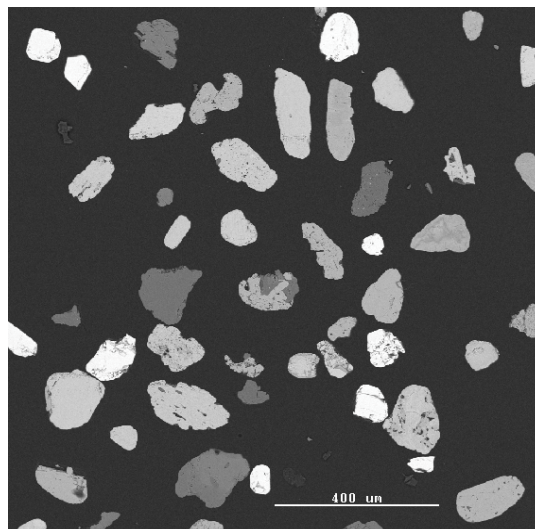


Figure 11. *Heavy minerals from sample VN47. The grey minerals are different Ti-minerals.*

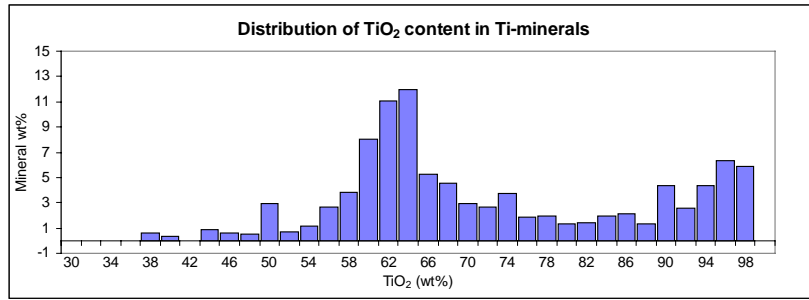


Figure 12. TiO₂ content in Ti minerals of sample VN47.

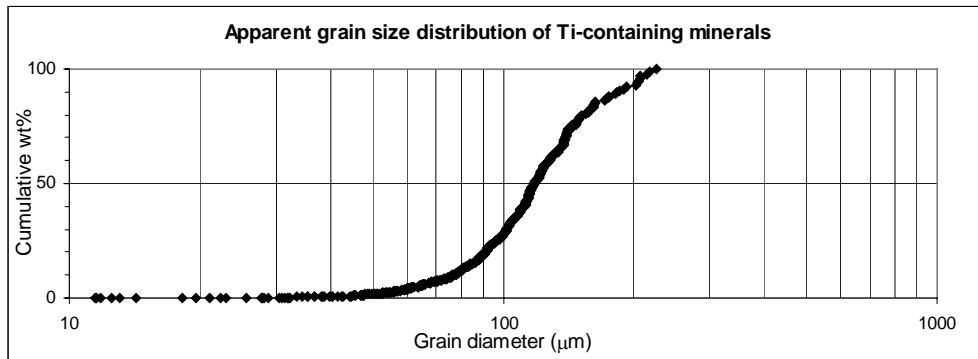


Figure 13. Grain size curve for sample VN 47.

Table 2. CCSEM data of sample VN47.

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	44,6	14,1	21,7	0,7	0,0	16,3	1,2	1,3	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	62,3	77,8	94,8	40,2
Fe ₂ O ₃ wt%	31,5	15,2	1,6	27,7
MnO wt%	2,9	1,1	0,1	0,8
Cr ₂ O ₃ wt%	0,1	0,1	0,1	0,0
SiO ₂ wt%	1,7	3,7	2,2	19,8
Al ₂ O ₃ wt%	0,9	1,5	0,9	9,6
MgO wt%	0,1	0,1	0,1	1,4
CaO wt%	0,1	0,1	0,1	0,2
ZrO ₂ wt%	0,5	0,3	0,2	0,2
Total	100,0	100,0	100,0	100,0

Weight percent on a mineral basis:		
Category	Heavy mineral	
	concentrate wt %	Raw sand wt %
Ilmenite	39,6	
Leucoxene	12,5	
Rutile	19,3	
Ti magnetite	0,6	
Magnetite	0,0	
Chromite	0,5	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,4	
Y-phosphate	0,1	
Sphene	0,0	
Garnet	0,0	
Kya/Sill	1,1	
Staurolite	1,1	
Zircon	14,5	
Silicate	7,8	
Unclassified	2,5	
Total	100,0	

Average TiO ₂ content of all the TiO ₂ minerals:	73,5
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	65,8
Valuable heavy minerals in raw sand:	53,54

Stockpile ilmenite

One of the tasks of the study was to determine the grain size of the ilmenite in the stockpile. The sieving results of the stockpile ilmenite (VN 36 – VN 45) and the ilmenite (VN 46) from the separation plant is shown in Table 3. Two sets of sieving intervals were done noted as 1 and 2 in Table 3.

Table 3. Sieving results of the ilmenite concentrates from the stockpile (VN36-45) and one sample from the separation plant (VN46).

Sample #	VN 36-VN 45	VN 36-VN 45	VN 36-VN 45	VN 46	VN 46	VN 46
mm	g	wt. %	Cumulative %	g	wt. %	Cumulative %
1						
>0,500	0,01	0,02	0,02	0,30	0,51	0,51
0,355	0,03	0,06	0,08	0,09	0,15	6,70
0,250	0,45	0,92	1,01	0,80	1,37	2,03
0,180	4,63	9,50	10,50	3,91	6,68	8,71
0,125	14,64	30,03	40,53	13,87	23,69	32,41
0,090	21,10	43,28	83,82	30,26	51,69	84,10
0,075	6,39	13,11	96,92	7,41	12,66	96,75
0,063	1,23	2,52	99,45	1,55	2,65	99,40
0,045	0,20	0,41	99,86	0,30	0,51	99,91
<0,045	0,07	0,14	100,00	0,05	0,09	100,00
2						
>0,250	0,49	1,01	1,01	1,19	2,03	2,03
0,150	10,45	21,44	22,45	8,21	14,02	16,05
0,106	19,37	39,73	62,18	25,32	43,25	59,30
0,075	16,94	34,75	96,93	21,92	37,44	96,74
0,063	1,23	2,52	99,45	1,55	2,65	99,39
0,045	0,20	0,41	99,86	0,30	0,51	99,90
<0,045	0,07	0,14	100,00	0,05	0,09	99,99

Around 20% of the ilmenite have a grains size lower than 100 μm (<0.1 mm). In the sieving interval from 0.075-0.106 mm 34.75% of the ilmenite fall into this interval (sieving test 2 in Table 3). The grain size of the raw sample 100-200 μm (VN47, Fig. x) has the main part of the minerals within this interval. This indicates that the ilmenite itself is more fine-grained than the average of the raw sample.

XRF of ilmenite

Four XRF analyses of the ilmenite were made: one composite sample of VN 36 - VN 45, VN 36, VN 45 and VN 46 respectively. The results are given in Table 4.

Table 4. XRF results of ilmenite

Sample_ID	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	Volat.	Sum major
VN36-45	2,572	56,612	1,994	32,856	2,203	0,174	0,028	0,000	0,026	0,195	0,300	96,960
VN46	0,714	58,602	0,918	33,900	2,520	0,051	0,000	0,000	0,000	0,129	0,730	97,564
VN36	1,913	57,592	1,346	33,713	2,259	0,109	0,018	0,000	0,010	0,167	-0,140	96,987
VN45	1,215	57,834	1,090	35,658	2,457	0,024	0,011	0,000	0,002	0,139	-0,270	98,160
	V	Cr	Ni	Zn	Rb	Sr	Y	Zr	Nb	Ba	Sum,	Total
											min.	
	754	878	32	415	0	112	646	2381	923	67	6504	97,610
	593	754	0	288	12	114	450	1083	938	97	4329	97,997
	740	772	0	380	10	118	613	2405	947	119	6402	97,627
	699	585	4	378	34	132	418	1599	885	63	4928	98,653

The TiO₂ content varies with up to 1% between the composite sample (VN 36 – VN 45) and the individual samples from the ilmenite stockpile (VN 36 and VN 45). The TiO₂ content of the ilmenite sample from the separation plant (VN 46) is 2% higher than the composite sample. The variation in TiO₂ grade follows the variation in SiO₂. The Al₂O₃ in ilmenite is c. 1%, the MgO content around 0.1% or less and the MnO contents are approximately 2.5%. Zircon varies from 0.1 – 0.25% and Cr, V, Y and Nb are all below 0.1%.

The difference in the 2% TiO₂ content between the raw sample and the ilmenite concentrate is probably due to the fact that the raw sample go through a separation process where zircon, monazite and rutile are separated out of the HM pre-concentrated sand. In this process we do not know in which fraction the leucoxene will be.

Conclusions

- The fieldwork carried out in Vietnam, May 2003 was focussed on the Ham Tan area, which covers parts of the provinces Binh Thuan and Vung Tau – Ba Ria in southern Vietnam. Altogether 35 samples of raw sand samples were collected. The heavy mineral content in the sands varies a lot within the areas. Most of the heavy mineral occurrences occur in aeolian sand dunes.
- The most promising area for heavy mineral resources is the area between Chum Gang and Tan Thang. These areas have the largest potential in tonnage and are not planned for other purposes such as industrialisation or urbanisation. The highest TiO₂ content in ilmenite around 59% is found in Chum Gang, Bau Doi A and Go Dinh 2.
- A special assignment was to collect samples of the ilmenite concentrate from the Ky Khang deposit, Ha Tinh province. The stockpile was a 15,000 tonne ilmenite heap where 10 samples were taken. XRF results of the ilmenite from the stockpile are given in this document. In addition, a CCSEM analysis is given of the raw sand, which is the basis for the ilmenite concentrate. This CCSEM analysis of the raw sample from Cam Xuyen has high-grade of TiO₂ with more than 60%.
- After discussions with DGMV it seems obvious that DGMV ought to have their own expert in heavy minerals. The heavy mineral business is so important to Vietnam that it would be very beneficial for the country to have experts themselves.
- During the meetings with different organisations in Vietnam it turned out that there is still areas with high-grade ilmenite in Vietnam e.g. the Hué region. The Marine and Mineral Resources Centre gave us this information about the new high-grade ilmenite placer deposits. The Centre will try to help to get this information verified. This Hué region has not been visited in our joint program but will be the next target for investigations.

Acknowledgement

I would like to acknowledge the General Director Mr. Tran Xuan Huong and his staff from the DGMV for a great help in the planning of the fieldwork in this joint project. Especially thanks go to the Deputy Director for 'Division for International Co-operation' Nguyen Xuan Hop and Ms. Bui Thi Huyen, International Co-operation Expert (interpreter) for all the administrative work and getting the permissions from the authorities to make this tour possible. My field companions Deputy Director Mr. Hop from DGMV, the interpreter and Senior Geologist Mr. Thien from the International Co-operation Department, DGMV and the ever talking and hard working driver, Mr. Tinh are thanked for their always-good humour and good company, which make the tour very enjoyable. The help from local institutions and field guides and various people during the fieldwork were indispensable and highly appreciated.



Figure 14. *The sampling has ended – thank you very much to my co-workers.*

References

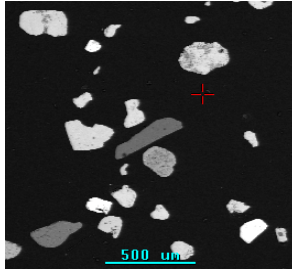
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Appendix

CCSEM analytical results



Geological Survey of Denmark and Greenland
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 Ph.: +45 38142000, Fax: +45 38142050



Sample Name:	2000370	No. of frames analysed:	81
Lab. Name:	2-370	No. of particles analysed:	1375
Date:	11/24/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/60x		
Guard region:	150µm		
Sieve:	100 µm ²		

Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	54.2	38.3	2.8	0.1	1.9	1.3	0.2	0.1	0.1	99.0
Leucoxene	73.3	9.7	0.9	0.1	9.4	4.4	0.1	0.2	0.5	98.5
Rutile	94.1	1.0	0.2	0.0	1.8	1.4	0.1	0.1	0.1	98.8
Ti magnetite	42.5	45.9	2.5	0.1	6.0	1.5	0.4	0.1	0.1	99.0
Magnetite	5.9	62.4	0.0	0.1	18.1	12.0	0.6	0.0	0.3	99.4
Chromite	0.6	29.9	0.5	45.9	1.0	12.6	6.9	0.1	0.4	97.9
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	3.2	15.0	0.7	0.1	40.4	20.7	1.1	17.1	0.0	98.4
Kya/Sill	0.1	1.0	0.3	0.1	43.0	53.4	0.1	0.0	0.3	98.3
Staurolite	0.3	14.7	0.5	0.1	37.5	45.4	1.1	0.1	0.0	99.7
Zircon	0.2	0.3	0.1	0.1	26.9	0.2	0.1	0.1	60.6	88.6
Silicate	1.8	8.2	0.2	0.1	52.8	27.8	3.1	1.9	0.1	96.0
Unclassified	17.2	7.2	1.2	1.3	25.6	20.2	1.9	0.3	18.3	91.1

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	72.8	6.3	3.6	2.0	5.9	9.2	0.2	0.0	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	54.8	74.4	95.2	42.9
Fe ₂ O ₃ wt%	38.7	9.8	1.0	46.3
MnO wt%	2.8	0.9	0.2	2.5
Cr ₂ O ₃ wt%	0.1	0.1	0.0	0.1
SiO ₂ wt%	2.0	9.6	1.8	6.0
Al ₂ O ₃ wt%	1.3	4.4	1.5	1.5
MgO wt%	0.2	0.1	0.1	0.4
CaO wt%	0.1	0.2	0.1	0.1
ZrO ₂ wt%	0.1	0.5	0.1	0.1
Total	100.0	100.0	100.0	100.0

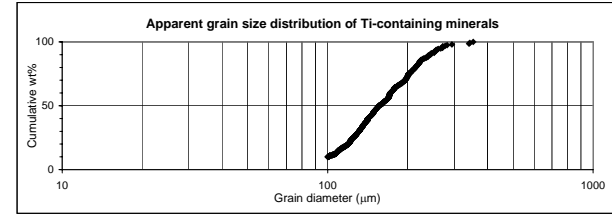
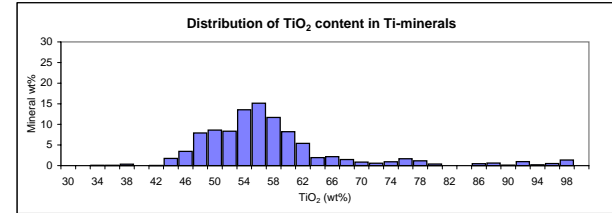
Average TiO ₂ content of all the TiO ₂ minerals:	57.6
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	56.0
Valuable heavy minerals in raw sand:	0.00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	62.5	
Leucoxene	5.4	
Rutile	3.1	
Ti magnetite	1.8	
Magnetite	0.4	
Chromite	0.1	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	5.1	
Kya/Sill	0.2	
Staurolite	0.0	
Zircon	7.9	
Silicate	11.1	
Unclassified	2.7	
Total	100.0	

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Lab. Name:	2-370	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/24/2003		



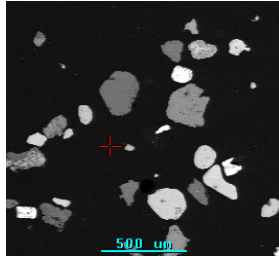
Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	Total grains
Ilmenite	1.6	1.7	536	201	15044	786
Leucoxene	1.6	1.9	540	210	14456	71
Rutile	1.5	1.7	549	202	15335	34
Ti magnetite	1.7	1.8	461	175	10752	29
Magnetite	1.3	1.6	749	264	28964	2
Chromite	1.4	1.6	429	154	9286	1
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.4	2.0	713	292	26468	41
Kya/Sill	3.0	2.9	829	366	19925	2
Staurolite	1.2	2.1	173	70	1127	1
Zircon	1.5	1.7	426	155	9604	150
Silicate	1.5	2.0	596	243	17529	203
Unclassified	1.7	2.2	597	249	15392	55



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GEUS

Sample Name:	2000372	No. of frames analysed:	81
Lab. Name:	2-372	No. of particles analysed:	895
Date:	11/24/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/60x		
Guard region:	200 µm		
Sieve:	100 µm ²		

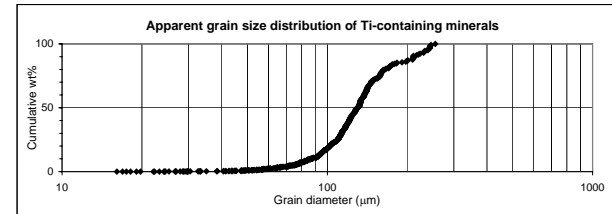
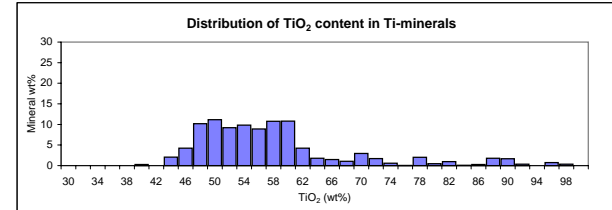


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GEUS

Lab. Name:	2-372	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/24/2003		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	54.4	38.0	2.8	0.1	2.2	1.0	0.2	0.1	0.1	99.0
Leucoxene	75.1	12.8	0.9	0.1	6.0	3.6	0.2	0.2	0.1	99.0
Rutile	92.5	1.8	0.1	0.1	2.4	1.5	0.1	0.1	0.1	98.8
Ti magnetite	44.4	43.9	4.3	0.1	4.0	1.7	0.4	0.1	0.1	99.0
Magnetite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	0.3	13.6	0.3	0.1	41.5	20.7	0.1	22.1	0.0	98.7
Kya/Sill	0.0	0.6	0.1	0.3	43.3	54.5	0.0	0.1	0.0	98.8
Staurolite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.2	0.2	0.1	0.1	27.1	0.1	0.1	0.1	60.4	88.5
Silicate	3.0	7.4	0.2	0.1	61.8	19.8	2.1	2.4	0.1	96.9
Unclassified	22.4	5.7	0.8	2.0	26.0	20.2	2.1	0.2	13.0	92.3

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	73.2	7.5	4.6	2.4	3.7	8.6	0.1	0.0	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	55.0	75.9	93.7	44.8
Fe ₂ O ₃ wt%	38.4	13.0	1.8	44.3
MnO wt%	2.8	0.9	0.1	4.4
Cr ₂ O ₃ wt%	0.1	0.1	0.1	0.1
SiO ₂ wt%	2.3	6.0	2.5	4.1
Al ₂ O ₃ wt%	1.0	3.6	1.5	1.8
MgO wt%	0.2	0.2	0.1	0.4
CaO wt%	0.1	0.2	0.1	0.1
ZrO ₂ wt%	0.1	0.1	0.1	0.1
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	58.5
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	56.6
Valuable heavy minerals in raw sand:	0.00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand wt %
Ilmenite	57.9	
Leucoxene	6.0	
Rutile	3.6	
Ti magnetite	1.9	
Magnetite	0.0	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	2.9	
Kya/Sill	0.1	
Staurolite	0.0	
Zircon	6.8	
Silicate	18.9	
Unclassified	2.0	
Total	100.0	

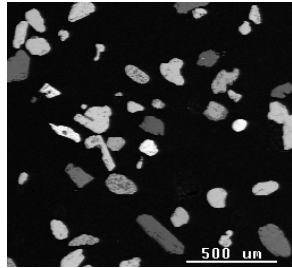
Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	Total grains
Ilmenite	1.6	1.7	433	162	9765	529
Leucoxene	1.6	1.8	518	199	13644	39
Rutile	1.4	1.5	449	157	14468	20
Ti magnetite	1.6	1.7	394	150	7965	20
Magnetite	0.0	0.0	0	0	0	0
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.4	2.1	579	237	14577	20
Kya/Sill	1.6	1.8	481	186	10074	1
Staurolite	0.0	0.0	0	0	0	0
Zircon	1.3	1.5	360	127	7315	80
Silicate	1.5	2.1	540	222	18125	158
Unclassified	1.5	2.1	497	207	11112	27



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GEUS

Sample Name:	2000373	No. of frames analysed:	36
Lab. Name:	2-373	No. of particles analysed:	992
Date:	11/23/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/60x		
Guard region:	150 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	53.8	38.0	3.0	0.1	2.4	1.3	0.2	0.1	0.1	99.0
Leucoxene	75.8	10.2	1.0	0.1	7.2	3.8	0.2	0.2	0.2	98.7
Rutile	94.3	1.0	0.1	0.1	1.7	1.2	0.1	0.1	0.1	98.6
Ti magnetite	40.8	39.2	2.3	0.1	13.2	2.2	0.3	0.1	0.6	98.9
Magnetite	4.1	85.9	0.3	0.0	4.8	3.6	0.0	0.1	0.4	99.2
Chromite	0.8	28.9	0.3	43.2	1.5	18.2	6.0	0.0	0.0	99.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	1.9	13.7	0.3	0.1	40.5	21.1	0.6	20.1	0.6	98.8
Kya/Sill	0.2	0.6	0.3	0.2	42.7	53.9	0.0	0.1	0.5	98.5
Staurolite	0.9	16.9	0.3	0.0	32.2	47.9	1.0	0.0	0.0	99.2
Zircon	0.2	0.3	0.1	0.1	26.9	0.2	0.1	0.1	60.2	88.3
Silicate	2.5	7.7	0.1	0.1	55.4	28.0	2.4	1.4	0.1	97.6
Unclassified	16.8	8.8	0.8	3.4	21.9	18.4	5.0	0.7	18.2	91.9

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	64.3	9.7	5.1	3.2	7.3	10.0	0.3	0.0	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	54.4	76.8	95.7	41.2
Fe ₂ O ₃ wt%	38.4	10.4	1.0	39.7
MnO wt%	3.0	1.0	0.1	2.4
Cr ₂ O ₃ wt%	0.1	0.1	0.1	0.1
SiO ₂ wt%	2.4	7.3	1.7	13.4
Al ₂ O ₃ wt%	1.3	3.9	1.2	2.2
MgO wt%	0.2	0.2	0.1	0.3
CaO wt%	0.1	0.2	0.1	0.1
ZrO ₂ wt%	0.1	0.2	0.1	0.7
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	59.1
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	56.6
Valuable heavy minerals in raw sand:	0.00

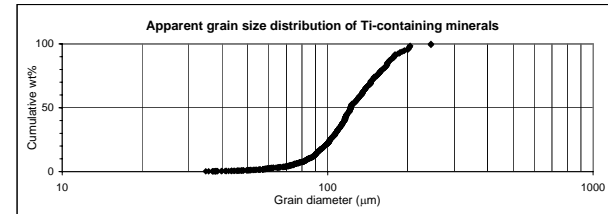
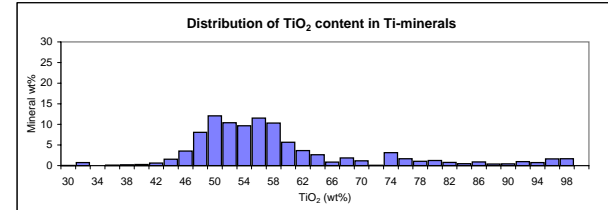
Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	55.4	
Leucoxene	8.3	
Rutile	4.4	
Ti magnetite	2.8	
Magnetite	0.3	
Chromite	0.1	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	6.3	
Kya/Sill	0.2	
Staurolite	0.0	
Zircon	8.6	
Silicate	12.1	
Unclassified	1.3	
Total	100.0	

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GEUS

Lab. Name:	2-373	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/23/2003		



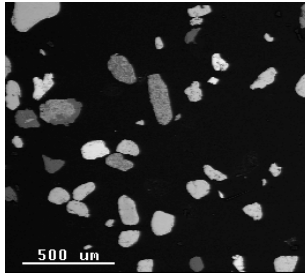
Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	
Ilmenite	1.6	1.7	420	157	9122	538
Leucoxene	1.4	1.9	546	211	13953	53
Rutile	1.5	1.7	381	140	7513	47
Ti magnetite	1.7	2.0	433	172	8287	28
Magnetite	1.5	1.7	385	145	8314	3
Chromite	1.5	1.7	314	118	5214	2
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.6	2.2	571	237	13624	46
Kya/Sill	3.9	3.2	746	331	13847	2
Staurolite	2.3	2.3	339	141	3934	1
Zircon	1.4	1.6	373	135	7622	97
Silicate	1.6	1.9	491	194	12305	148
Unclassified	1.5	1.8	358	143	7117	27



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GEUS

Sample Name:	2000375	No. of frames analysed:	21
Lab. Name:	2-375	No. of particles analysed:	639
Date:	11/23/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analysed by:	JK		
Acc. Voltage/Magnification:	17kV/60x		
Guard region:	150 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	53.8	38.3	3.1	0.0	2.4	1.0	0.4	0.1	0.1	99.2
Leucoxene	73.1	9.2	0.8	0.1	10.5	3.9	0.5	0.3	0.3	98.5
Rutile	92.7	1.9	0.1	0.1	2.4	1.6	0.1	0.1	0.1	99.1
Ti magnetite	40.8	39.1	2.5	0.0	9.7	5.0	0.6	0.3	0.8	98.8
Magnetite	0.4	67.4	0.2	0.0	9.7	0.7	0.2	0.3	0.2	79.2
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	1.4	15.9	0.5	0.1	39.9	19.1	0.6	20.6	0.1	98.2
Kya/Sill	0.1	0.8	0.1	0.0	42.9	53.6	0.0	0.1	0.0	97.6
Staurolite	1.0	17.6	0.6	0.0	29.3	48.6	1.4	0.0	0.0	98.6
Zircon	0.2	0.4	0.1	0.1	27.9	0.3	0.1	0.0	60.6	89.7
Silicate	2.7	3.9	0.2	0.0	77.5	11.0	1.1	0.6	0.0	97.0
Unclassified	11.2	12.2	0.4	0.1	24.1	3.7	1.2	0.6	17.7	71.3

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	66.8	3.7	4.3	4.7	6.4	13.4	0.2	0.5	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	54.2	74.2	93.5	41.2
Fe ₂ O ₃ wt%	38.6	9.3	1.9	39.6
MnO wt%	3.1	0.8	0.1	2.6
Cr ₂ O ₃ wt%	0.0	0.1	0.1	0.0
SiO ₂ wt%	2.4	10.6	2.4	9.9
Al ₂ O ₃ wt%	1.0	3.9	1.7	5.0
MgO wt%	0.4	0.5	0.1	0.6
CaO wt%	0.1	0.3	0.1	0.3
ZrO ₂ wt%	0.1	0.3	0.1	0.8
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	56.5
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	54.4
Valuable heavy minerals in raw sand:	0.00

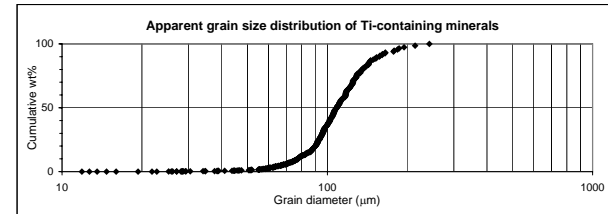
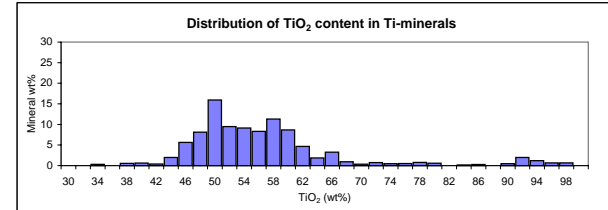
Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	58.0	
Leucoxene	3.2	
Rutile	3.7	
Ti magnetite	4.0	
Magnetite	0.1	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	5.6	
Kya/Sill	0.2	
Staurolite	0.5	
Zircon	11.7	
Silicate	11.8	
Unclassified	1.3	
Total	100.0	

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GEUS

Lab. Name:	2-375	Analyzed by:	JK
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/23/2003		



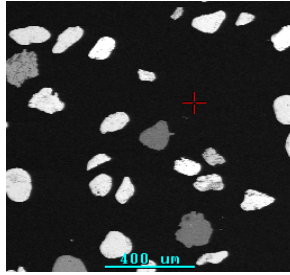
Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	Total grains
Ilmenite	1.5	1.7	379	140	7493	365
Leucoxene	1.6	1.8	365	139	6873	22
Rutile	1.4	1.7	415	153	8756	18
Ti magnetite	1.6	2.1	480	200	9452	19
Magnetite	1.4	1.7	136	50	999	3
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.5	2.1	504	210	10598	28
Kya/Sill	1.4	2.6	419	179	5472	2
Staurolite	1.9	2.6	926	396	26496	1
Zircon	1.6	1.7	367	135	6910	77
Silicate	1.5	2.1	499	204	10985	86
Unclassified	1.6	1.9	330	131	5757	18



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GEUS

Sample Name:	2000376	No. of frames analysed:	77
Lab. Name:	2-376	No. of particles analysed:	1837
Date:	11/12/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	125 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	53.5	39.1	3.0	0.1	1.7	0.9	0.3	0.1	0.1	98.8
Leucoxene	74.6	8.6	0.6	0.1	9.3	4.0	0.5	0.1	0.3	98.2
Rutile	94.2	0.9	0.2	0.1	1.8	0.9	0.1	0.1	0.2	98.5
Ti magnetite	43.1	43.5	2.6	0.1	6.1	1.5	0.4	0.6	0.7	98.7
Magnetite	5.2	74.8	0.3	0.2	13.4	3.1	0.5	0.1	0.4	98.0
Chromite	0.5	34.9	0.2	38.7	1.0	18.5	5.4	0.0	0.0	99.3
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	1.3	13.7	0.3	0.2	40.9	21.7	1.2	18.6	0.1	98.0
Kya/Sill	0.2	0.7	0.3	0.0	42.2	54.6	0.0	0.3	0.3	98.6
Staurolite	0.6	15.2	0.2	0.0	33.5	48.4	1.2	0.1	0.0	99.1
Zircon	0.2	0.3	0.1	0.1	27.0	0.2	0.1	0.1	61.0	89.1
Silicate	1.4	3.3	0.2	0.1	81.3	9.5	1.3	0.6	0.1	97.8
Unclassified	11.9	8.8	0.6	0.8	23.2	8.7	1.5	3.9	24.3	83.6

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	67.2	6.7	3.9	5.8	3.0	12.9	0.3	0.3	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	54.2	75.9	95.6	43.7
Fe ₂ O ₃ wt%	39.6	8.8	0.9	44.1
MnO wt%	3.0	0.7	0.2	2.6
Cr ₂ O ₃ wt%	0.1	0.1	0.1	0.1
SiO ₂ wt%	1.7	9.5	1.9	6.2
Al ₂ O ₃ wt%	0.9	4.1	0.9	1.6
MgO wt%	0.3	0.5	0.1	0.4
CaO wt%	0.1	0.1	0.1	0.6
ZrO ₂ wt%	0.1	0.3	0.2	0.8
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	57.1
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	55.3
Valuable heavy minerals in raw sand:	0.00

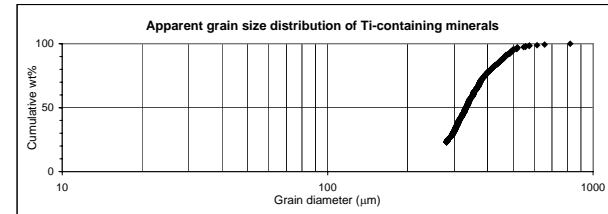
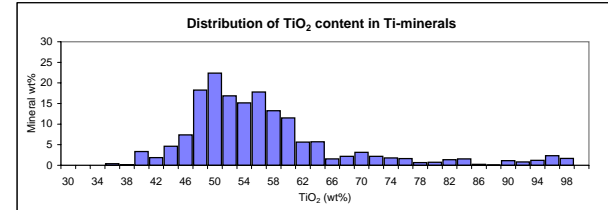
Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	51.3	
Leucoxene	5.1	
Rutile	3.0	
Ti magnetite	4.4	
Magnetite	1.0	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	2.3	
Kya/Sill	0.2	
Staurolite	0.2	
Zircon	9.8	
Silicate	20.5	
Unclassified	2.1	
Total	100.0	

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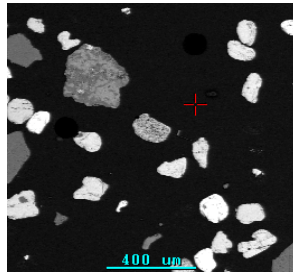
Lab. Name:	2-376	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/12/2003		



Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	Total grains
Ilmenite	1.6	1.7	1152	427	68234	991
Leucoxene	1.5	1.8	1417	547	98199	69
Rutile	1.6	1.7	1107	419	63016	55
Ti magnetite	1.7	1.9	1361	529	85743	65
Magnetite	1.5	1.6	966	362	56212	21
Chromite	1.5	1.7	917	347	38681	1
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.4	2.0	1510	608	106856	30
Kya/Sill	1.6	1.9	1429	564	93836	4
Staurolite	1.3	2.0	1694	670	128813	3
Zircon	1.5	1.6	1035	376	57859	214
Silicate	1.5	2.0	1747	702	142469	327
Unclassified	1.5	1.7	1142	447	76958	57



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Sample Name:	2000377	No. of frames analysed:	60
Lab. Name:	2-377	No. of particles analysed:	1137
Date:	11/13/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	150 µm		
Sieve:	100 µm ²		

Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	54.3	39.1	3.0	0.1	1.3	0.7	0.2	0.1	0.2	98.9
Leucoxene	74.3	13.5	0.9	0.1	5.5	3.4	0.3	0.1	0.2	98.3
Rutile	94.5	1.0	0.2	0.0	1.8	0.9	0.1	0.1	0.1	98.8
Ti magnetite	42.2	44.7	3.2	0.1	5.3	1.3	0.1	0.1	1.0	98.0
Magnetite	7.7	82.5	0.4	0.1	5.1	1.8	0.7	0.2	0.1	98.6
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	1.0	18.7	0.2	0.0	41.7	20.5	1.6	14.5	0.1	98.4
Kya/Sill	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Staurolite	0.7	14.2	0.2	0.3	34.7	46.2	1.9	0.1	0.2	98.6
Zircon	0.3	0.3	0.2	0.1	27.1	0.1	0.1	0.1	60.8	89.0
Silicate	1.4	3.2	0.2	0.1	82.1	9.2	0.8	0.6	0.1	97.7
Unclassified	7.7	5.3	0.8	0.2	21.2	3.4	0.3	8.7	36.0	83.7

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	69.3	4.7	2.7	5.5	1.7	15.8	0.0	0.2	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	54.9	75.6	95.7	43.0
Fe ₂ O ₃ wt%	39.5	13.8	1.0	45.6
MnO wt%	3.0	0.9	0.2	3.2
Cr ₂ O ₃ wt%	0.1	0.1	0.0	0.1
SiO ₂ wt%	1.3	5.6	1.8	5.5
Al ₂ O ₃ wt%	0.7	3.4	0.9	1.4
MgO wt%	0.2	0.3	0.1	0.1
CaO wt%	0.1	0.1	0.1	0.1
ZrO ₂ wt%	0.2	0.2	0.1	1.0
Total	100.0	100.0	100.0	100.0

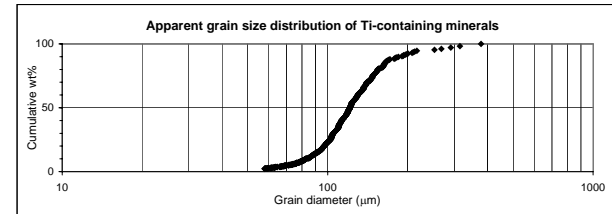
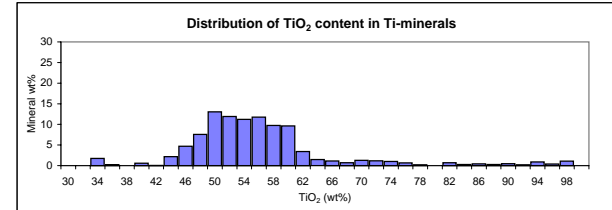
Average TiO ₂ content of all the TiO ₂ minerals:	56.6
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	55.3
Valuable heavy minerals in raw sand:	0.00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	59.0	
Leucoxene	4.0	
Rutile	2.3	
Ti magnetite	4.7	
Magnetite	0.4	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	1.4	
Kya/Sill	0.0	
Staurolite	0.2	
Zircon	13.5	
Silicate	11.2	
Unclassified	3.4	
Total	100.0	

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Lab. Name:	2-377	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/13/2003		



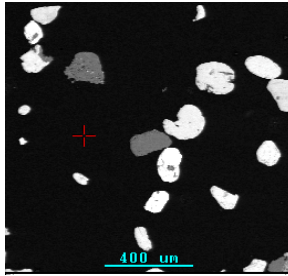
Category	Average grain parameters				Total grains	
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)		
Ilmenite	1.5	1.7	401	148	8604	671
Leucoxene	1.6	1.8	484	184	11771	33
Rutile	1.5	1.8	472	175	10824	19
Ti magnetite	1.6	1.9	445	177	10599	41
Magnetite	1.4	1.6	333	126	6024	5
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.4	1.9	618	245	17597	9
Kya/Sill	0.0	0.0	0	0	0	0
Staurolite	1.6	1.7	243	94	3242	6
Zircon	1.4	1.6	361	131	7048	181
Silicate	1.5	2.1	533	217	14164	131
Unclassified	1.5	2.1	498	212	13709	41



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Sample Name:	2000379	No. of frames analysed:	45
Lab. Name:	2-379	No. of particles analysed:	641
Date:	11/17/2003	Heavy minerals in raw sand (%):	0.00
Submitter:	Henrik Stendal	Country:	Vietnam
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	150 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	54.0	37.8	3.0	0.1	2.5	1.2	0.2	0.1	0.2	98.9
Leucoxene	77.9	6.6	0.4	0.1	9.1	3.8	0.2	0.1	0.1	98.4
Rutile	93.4	1.4	0.3	0.1	1.7	1.4	0.0	0.1	0.2	98.6
Ti magnetite	43.3	44.5	2.9	0.1	2.8	3.0	0.1	0.1	1.9	98.6
Magnetite	0.9	96.5	0.0	0.1	0.6	0.6	0.1	0.1	0.1	99.2
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	1.1	13.7	0.3	0.1	40.0	21.9	0.5	21.3	0.0	98.9
Kya/Sill	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Staurolite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.2	0.3	0.2	0.1	27.0	0.2	0.1	0.2	60.8	88.9
Silicate	3.5	6.8	0.2	0.1	63.6	18.7	3.2	1.9	0.1	98.1
Unclassified	14.4	5.1	0.3	0.3	27.1	4.2	0.4	1.7	16.9	70.4

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	68.6	7.5	4.7	2.5	5.4	11.4	0.0	0.0	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	54.6	79.2	94.7	43.9
Fe ₂ O ₃ wt%	38.2	6.7	1.4	45.1
MnO wt%	3.0	0.4	0.3	2.9
Cr ₂ O ₃ wt%	0.1	0.1	0.1	0.1
SiO ₂ wt%	2.5	9.2	1.8	2.9
Al ₂ O ₃ wt%	1.2	3.9	1.4	3.0
MgO wt%	0.2	0.2	0.0	0.1
CaO wt%	0.1	0.1	0.1	0.1
ZrO ₂ wt%	0.2	0.1	0.2	1.9
Total	100.0	100.0	100.0	100.0

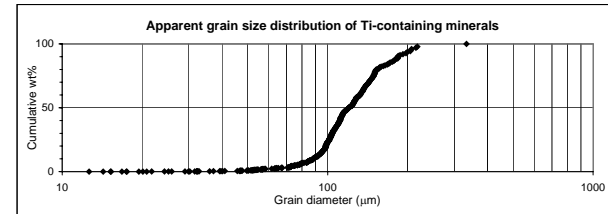
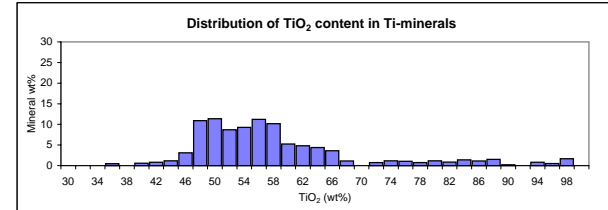
Average TiO ₂ content of all the TiO ₂ minerals:	58.8
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	56.6
Valuable heavy minerals in raw sand:	0.00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand wt %
Ilmenite	56.9	
Leucoxene	6.2	
Rutile	3.9	
Ti magnetite	2.1	
Magnetite	0.4	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	4.4	
Kya/Sill	0.0	
Staurolite	0.0	
Zircon	9.4	
Silicate	14.7	
Unclassified	2.0	
Total	100.0	

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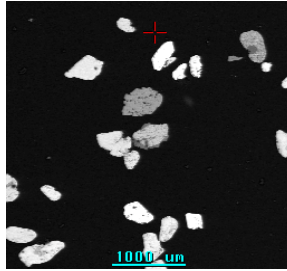
Lab. Name:	2-379	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/17/2003		



Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	Total grains
Ilmenite	1.6	1.8	423	161	9106	368
Leucoxene	1.6	1.9	494	193	11418	32
Rutile	1.6	1.8	483	182	11496	18
Ti magnetite	1.8	2.2	485	197	8812	13
Magnetite	1.7	1.5	361	128	6714	3
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.5	2.1	512	213	13380	22
Kya/Sill	0.0	0.0	0	0	0	0
Staurolite	0.0	0.0	0	0	0	0
Zircon	1.4	1.6	359	128	7066	76
Silicate	1.6	2.2	627	255	17061	86
Unclassified	1.5	2.0	418	171	8503	23



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Sample Name:	2000380	No. of frames analysed:	32
Lab. Name:	2-380	No. of particles analysed:	710
Date:	11/12/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	125 µm		
Sieve:	100 µm ²		

Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	53.6	38.1	2.5	0.2	1.8	1.0	0.3	0.1	0.3	98.1
Leucoxene	73.7	8.7	0.8	0.2	9.2	4.4	0.2	0.1	0.5	97.7
Rutile	93.2	0.7	0.2	0.2	1.7	1.3	0.1	0.1	0.2	97.6
Ti magnetite	42.3	45.1	2.9	0.3	3.7	1.6	0.1	0.1	1.5	97.6
Magnetite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	0.9	11.8	0.3	0.4	41.0	20.8	0.3	21.7	0.4	97.5
Kya/Sill	0.4	0.9	0.2	0.1	42.0	53.5	0.0	0.3	0.0	97.4
Staurolite	0.3	13.7	0.3	0.1	33.2	49.8	1.3	0.0	0.0	98.8
Zircon	0.2	0.4	0.2	0.2	26.9	0.1	0.1	0.1	60.7	89.1
Silicate	2.7	4.2	0.3	0.2	68.1	15.2	2.2	0.9	0.3	94.1
Unclassified	9.4	3.4	0.6	1.2	24.4	3.4	1.1	3.2	34.0	80.8

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	74.2	5.0	2.4	5.4	0.4	11.1	0.6	0.8	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	54.7	75.4	95.4	43.4
Fe ₂ O ₃ wt%	38.9	8.9	0.7	46.2
MnO wt%	2.6	0.8	0.2	2.9
Cr ₂ O ₃ wt%	0.2	0.2	0.2	0.3
SiO ₂ wt%	1.9	9.5	1.8	3.8
Al ₂ O ₃ wt%	1.1	4.5	1.3	1.6
MgO wt%	0.3	0.2	0.1	0.1
CaO wt%	0.1	0.1	0.1	0.1
ZrO ₂ wt%	0.3	0.5	0.2	1.6
Total	100.0	100.0	100.0	100.0

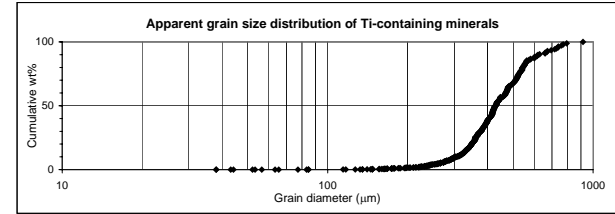
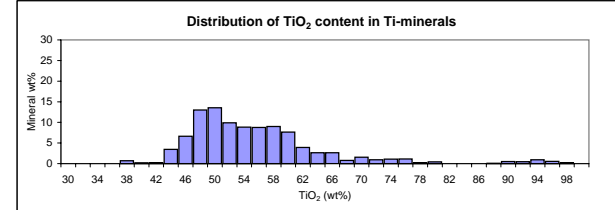
Average TiO ₂ content of all the TiO ₂ minerals:	56.3
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	55.2
Valuable heavy minerals in raw sand:	0.00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	61.7	
Leucoxene	4.2	
Rutile	2.0	
Ti magnetite	4.5	
Magnetite	0.0	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	0.3	
Kya/Sill	0.5	
Staurolite	0.7	
Zircon	9.3	
Silicate	11.5	
Unclassified	5.2	
Total	100.0	

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Lab. Name:	2-380	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/12/2003		

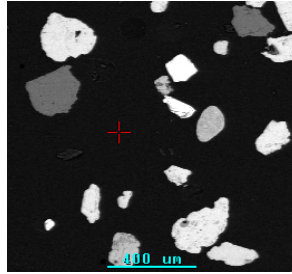


Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	
Ilmenite	1.5	1.8	1552	589	117838	417
Leucoxene	1.5	1.9	1875	733	165916	20
Rutile	1.5	1.7	1581	587	119406	12
Ti magnetite	1.7	1.9	1530	603	105216	32
Magnetite	0.0	0.0	0	0	0	0
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.2	1.9	1045	433	60796	5
Kya/Sill	1.5	3.3	3437	1531	286684	2
Staurolite	1.5	1.6	2094	765	216072	3
Zircon	1.4	1.6	1387	495	105026	68
Silicate	1.5	1.9	1900	767	179113	87
Unclassified	1.5	1.9	1635	651	128566	54



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Sample Name:	2000382	No. of frames analysed:	81
Lab. Name:	2-382	No. of particles analysed:	1520
Date:	11/17/2003	Heavy minerals in raw sand (%):	0.00
Submitter:	Henrik Stendal	Country:	Vietnam
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	150 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	53.6	39.3	3.2	0.1	1.3	1.0	0.2	0.1	0.2	98.9
Leucoxene	75.0	10.3	1.0	0.1	8.0	3.7	0.2	0.1	0.3	98.8
Rutile	93.0	1.6	0.3	0.1	2.1	1.3	0.1	0.1	0.1	98.7
Ti magnetite	42.7	41.9	3.0	0.1	5.4	2.0	0.7	0.2	1.8	97.6
Magnetite	0.4	76.7	0.3	0.2	9.6	10.0	0.3	0.4	0.7	98.7
Chromite	0.4	29.0	0.2	56.6	0.4	7.7	2.8	0.1	0.0	97.3
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	1.2	14.8	1.9	0.1	39.2	20.7	0.4	20.3	0.0	98.7
Kya/Sill	0.1	0.4	0.0	0.2	43.1	53.6	0.1	0.1	0.2	97.8
Staurolite	1.0	14.1	0.2	0.3	36.3	44.7	0.6	0.0	0.8	98.0
Zircon	0.3	0.3	0.1	0.1	27.0	0.2	0.1	0.1	60.7	88.9
Silicate	1.3	4.9	0.2	0.1	75.3	13.0	1.9	1.0	0.1	97.8
Unclassified	17.2	6.3	1.4	0.3	24.9	2.9	0.5	3.6	25.1	82.1

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	70.1	5.0	2.3	5.0	2.0	15.2	0.2	0.1	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	54.2	75.9	94.2	43.7
Fe ₂ O ₃ wt%	39.7	10.4	1.6	42.9
MnO wt%	3.2	1.0	0.3	3.1
Cr ₂ O ₃ wt%	0.1	0.1	0.1	0.1
SiO ₂ wt%	1.3	8.1	2.2	5.5
Al ₂ O ₃ wt%	1.0	3.7	1.3	2.0
MgO wt%	0.2	0.2	0.1	0.7
CaO wt%	0.1	0.1	0.1	0.2
ZrO ₂ wt%	0.2	0.3	0.1	1.8
Total	100.0	100.0	100.0	100.0

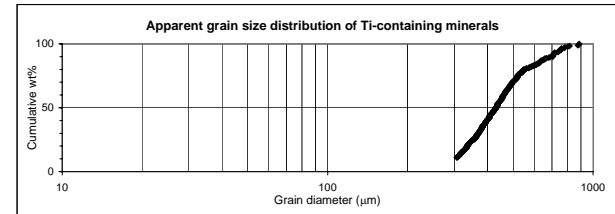
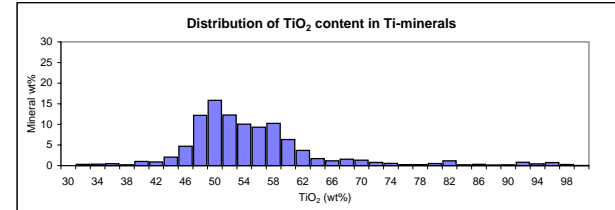
Average TiO ₂ content of all the TiO ₂ minerals:	56.0
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	54.9
Valuable heavy minerals in raw sand:	0.00

Weight percent on a mineral basis:		
Category	Heavy mineral	
	concentrate	Raw sand
Ilmenite	58.7	
Leucoxene	4.2	
Rutile	1.9	
Ti magnetite	4.2	
Magnetite	0.4	
Chromite	0.1	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	1.7	
Kya/Sill	0.2	
Staurolite	0.1	
Zircon	12.7	
Silicate	13.7	
Unclassified	2.0	
Total	100.0	

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Lab. Name:	2-382	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/17/2003		



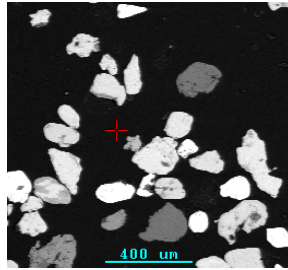
Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	
Ilmenite	1.5	1.9	1506	591	107976	856
Leucoxene	1.5	2.0	1653	649	121759	55
Rutile	1.5	2.1	1720	691	120216	23
Ti magnetite	1.7	2.0	1546	627	106769	59
Magnetite	1.7	2.2	1754	726	153417	4
Chromite	1.4	1.5	1420	504	103823	2
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.4	2.1	1445	598	90715	32
Kya/Sill	1.4	1.9	1486	590	96231	4
Staurolite	1.2	1.5	1517	538	118641	1
Zircon	1.5	1.7	1338	501	92476	211
Silicate	1.5	2.1	1865	759	161641	227
Unclassified	1.6	2.2	1624	680	115191	46



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Sample Name:	2000385	No. of frames analysed:	46
Lab. Name:	2-385	No. of particles analysed:	752
Date:	11/17/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	150 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	53.3	38.8	3.1	0.1	1.9	1.2	0.2	0.1	0.2	98.9
Leucoxene	74.6	9.6	0.5	0.0	9.1	4.6	0.2	0.1	0.1	98.7
Rutile	93.2	1.1	0.2	0.1	2.5	1.3	0.1	0.1	0.2	98.8
Ti magnetite	40.6	40.8	3.2	0.0	8.6	1.7	0.5	0.3	2.8	98.6
Magnetite	0.7	80.6	0.2	0.0	7.3	9.4	0.3	0.1	0.1	98.7
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	1.0	17.0	0.2	0.2	40.3	20.2	1.8	17.0	0.2	98.0
Kya/Sill	0.2	0.4	0.2	0.1	42.9	54.0	0.1	0.1	0.3	98.2
Staurolite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.2	0.3	0.2	0.1	27.1	0.1	0.1	0.2	60.8	89.0
Silicate	3.7	11.8	0.3	0.1	50.5	22.6	4.8	3.6	0.2	97.6
Unclassified	9.7	14.3	0.9	3.0	18.3	16.4	3.8	1.1	21.9	89.3

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	75.1	3.6	2.0	4.3	4.7	10.0	0.4	0.0	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	53.9	75.6	94.4	41.2
Fe ₂ O ₃ wt%	39.3	9.7	1.2	41.4
MnO wt%	3.1	0.5	0.2	3.3
Cr ₂ O ₃ wt%	0.1	0.0	0.1	0.0
SiO ₂ wt%	1.9	9.2	2.5	8.7
Al ₂ O ₃ wt%	1.2	4.6	1.3	1.7
MgO wt%	0.2	0.2	0.1	0.5
CaO wt%	0.1	0.1	0.1	0.3
ZrO ₂ wt%	0.2	0.1	0.2	2.8
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	55.1
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	54.2
Valuable heavy minerals in raw sand:	0.00

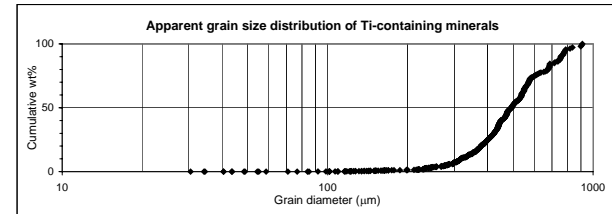
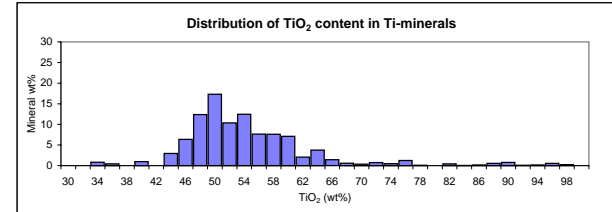
Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	64.0	
Leucoxene	3.0	
Rutile	1.7	
Ti magnetite	3.7	
Magnetite	0.8	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	4.0	
Kya/Sill	0.4	
Staurolite	0.0	
Zircon	8.6	
Silicate	10.7	
Unclassified	3.2	
Total	100.0	

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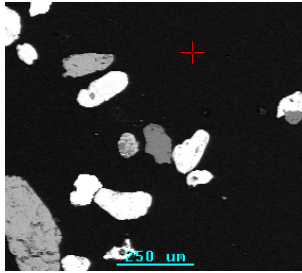
Lab. Name:	2-385	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/17/2003		



Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	
Ilmenite	1.6	2.1	1804	727	138528	441
Leucoxene	1.6	1.9	1639	636	131982	22
Rutile	1.4	1.8	1445	552	103223	14
Ti magnetite	1.6	2.6	2203	943	173284	19
Magnetite	1.4	2.0	1709	680	129914	5
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.5	2.2	1646	692	115123	37
Kya/Sill	1.3	1.7	1545	559	116347	4
Staurolite	0.0	0.0	0	0	0	0
Zircon	1.6	2.1	1760	701	127671	62
Silicate	1.5	2.1	1890	779	161377	107
Unclassified	1.6	2.1	1738	728	165430	31



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Sample Name:	2000387	No. of frames analysed:	81
Lab. Name:	2-387	No. of particles analysed:	675
Date:	11/18/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/100x		
Guard region:	150 µm		
Sieve:	100 µm ²		

Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	55.0	37.6	2.9	0.1	1.8	1.2	0.2	0.1	0.1	99.0
Leucoxene	78.6	7.3	0.8	0.2	6.8	4.0	0.1	0.1	0.4	98.4
Rutile	93.6	1.0	0.1	0.1	2.2	1.4	0.1	0.1	0.1	98.7
Ti magnetite	41.6	34.1	3.6	0.1	13.2	3.0	0.2	0.1	2.3	98.3
Magnetite	2.8	69.7	0.3	0.3	10.3	9.2	0.8	0.3	1.8	95.4
Chromite	0.3	37.7	0.3	41.5	0.6	12.3	6.7	0.2	0.0	99.5
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	3.6	16.0	0.3	0.1	40.2	21.3	1.3	15.2	0.1	98.2
Kya/Sill	0.2	0.7	0.1	0.3	42.9	54.0	0.1	0.0	0.3	98.6
Staurolite	0.6	14.9	0.0	0.0	32.2	49.5	1.2	0.1	0.5	98.9
Zircon	0.3	0.4	0.1	0.1	27.0	0.2	0.1	0.1	60.7	89.0
Silicate	4.6	10.8	0.3	0.1	50.5	24.8	4.1	2.4	0.1	97.7
Unclassified	15.7	5.7	0.5	1.0	22.6	10.1	1.8	0.4	21.2	78.9

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	71.6	3.2	3.6	2.3	3.4	15.0	0.5	0.3	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	55.6	79.9	94.8	42.3
Fe ₂ O ₃ wt%	37.9	7.4	1.0	34.7
MnO wt%	3.0	0.9	0.1	3.6
Cr ₂ O ₃ wt%	0.1	0.2	0.1	0.1
SiO ₂ wt%	1.8	6.9	2.2	13.5
Al ₂ O ₃ wt%	1.2	4.1	1.4	3.1
MgO wt%	0.2	0.1	0.1	0.2
CaO wt%	0.1	0.1	0.1	0.1
ZrO ₂ wt%	0.1	0.4	0.1	2.3
Total	100.0	100.0	100.0	100.0

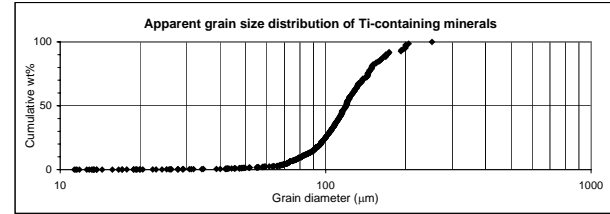
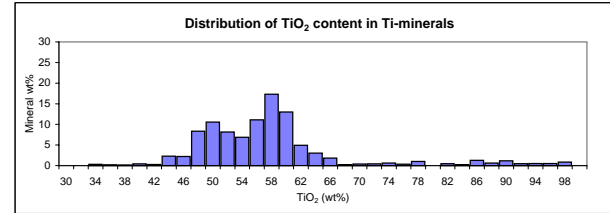
Average TiO ₂ content of all the TiO ₂ minerals:	57.9
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	56.2
Valuable heavy minerals in raw sand:	0.00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	61.6	
Leucoxene	2.8	
Rutile	3.1	
Ti magnetite	2.0	
Magnetite	0.7	
Chromite	0.1	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	3.0	
Kya/Sill	0.4	
Staurolite	0.2	
Zircon	12.9	
Silicate	9.9	
Unclassified	3.4	
Total	100.0	

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Lab. Name:	2-387	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/18/2003		



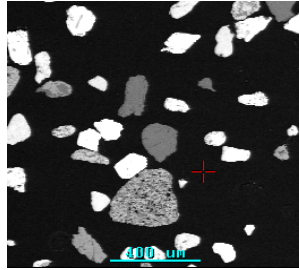
Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	Total grains
Ilmenite	1.5	1.8	408	158	8254	399
Leucoxene	1.5	1.8	502	193	11502	13
Rutile	1.4	1.9	424	166	8371	18
Ti magnetite	1.6	2.5	461	194	8348	12
Magnetite	1.4	1.8	479	195	15236	2
Chromite	1.1	1.3	213	65	2695	1
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.6	2.1	417	173	10496	17
Kya/Sill	1.3	1.6	422	164	10748	3
Staurolite	1.4	1.8	401	155	7052	2
Zircon	1.5	1.8	367	140	6619	101
Silicate	1.6	2.5	597	252	13419	67
Unclassified	1.7	2.4	488	206	9408	32



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GEUS

Sample Name:	2000388	No. of frames analysed:	27
Lab. Name:	2-388	No. of particles analysed:	960
Date:	19-11-203	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	150 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	53.6	38.5	3.0	0.1	1.8	1.1	0.2	0.1	0.3	98.7
Leucoxene	74.4	10.7	1.0	0.1	7.3	4.4	0.2	0.1	0.3	98.5
Rutile	93.8	1.4	0.3	0.0	1.9	1.0	0.1	0.1	0.1	98.8
Ti magnetite	42.6	39.3	3.0	0.1	6.5	1.4	0.1	0.1	4.0	97.4
Magnetite	0.4	67.6	0.0	0.0	17.1	7.2	5.2	0.5	0.0	98.1
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	38.1	3.9	0.6	0.0	29.0	1.1	0.1	26.8	0.0	99.5
Garnet	0.8	13.9	1.7	0.2	40.5	22.1	1.3	17.1	0.2	98.0
Kya/Sill	0.4	0.7	0.2	0.1	42.3	54.8	0.1	0.1	0.0	98.6
Staurolite	0.9	14.5	0.2	0.0	31.4	49.8	1.0	0.1	0.0	98.0
Zircon	0.2	0.4	0.2	0.1	26.9	0.1	0.1	0.1	60.5	88.6
Silicate	4.2	10.1	0.3	0.1	51.7	22.9	4.1	4.0	0.1	97.4
Unclassified	15.0	8.5	0.6	0.4	22.0	9.6	1.1	1.6	27.5	86.1

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	69.4	5.8	2.9	5.8	2.9	12.0	1.1	0.1	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	54.4	75.5	94.9	43.8
Fe ₂ O ₃ wt%	39.0	10.9	1.4	40.4
MnO wt%	3.1	1.0	0.3	3.1
Cr ₂ O ₃ wt%	0.1	0.1	0.0	0.1
SiO ₂ wt%	1.8	7.4	1.9	6.7
Al ₂ O ₃ wt%	1.2	4.5	1.0	1.5
MgO wt%	0.2	0.2	0.1	0.2
CaO wt%	0.1	0.1	0.1	0.1
ZrO ₂ wt%	0.3	0.3	0.1	4.1
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	56.5
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	55.1
Valuable heavy minerals in raw sand:	0.00

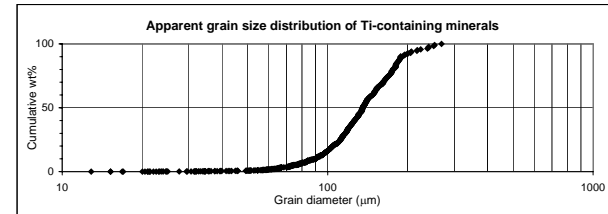
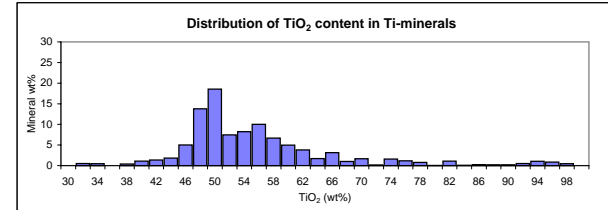
Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	59.3	
Leucoxene	5.0	
Rutile	2.5	
Ti magnetite	4.9	
Magnetite	0.2	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.1	
Garnet	2.5	
Kya/Sill	0.9	
Staurolite	0.1	
Zircon	10.3	
Silicate	9.6	
Unclassified	4.6	
Total	100.0	

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GEUS

Lab. Name:	2-388	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	19-11-203		

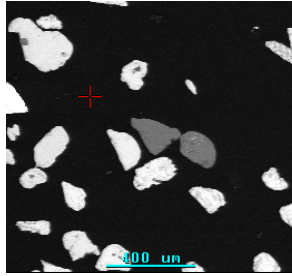


Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	Total grains
Ilmenite	1.5	1.7	454	171	10470	539
Leucoxene	1.6	1.9	526	205	12423	38
Rutile	1.5	1.5	375	135	8201	26
Ti magnetite	1.6	2.2	616	251	14789	30
Magnetite	2.2	2.0	715	287	20257	1
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	1.5	1.8	619	236	17358	1
Garnet	1.5	1.7	369	144	7810	34
Kya/Sill	1.8	2.1	602	242	14929	8
Staurolite	2.3	2.2	586	242	12235	1
Zircon	1.5	1.7	406	148	8533	111
Silicate	1.5	1.9	525	206	13235	117
Unclassified	1.6	2.3	634	272	15199	48



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Sample Name:	2000389	No. of frames analysed:	70
Lab. Name:	2-389	No. of particles analysed:	1218
Date:	11/14/2003	Heavy minerals in raw sand (%):	0.00
Submitter:	Henrik Stendal	Country:	Vietnam
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	150 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	53.4	39.8	3.4	0.1	1.1	0.8	0.2	0.1	0.1	99.0
Leucoxene	74.5	13.4	1.1	0.1	5.7	3.1	0.4	0.2	0.1	98.6
Rutile	91.2	1.1	0.3	0.0	3.4	1.7	0.2	0.1	0.2	98.2
Ti magnetite	43.1	43.4	2.8	0.1	6.6	1.5	0.3	0.5	0.5	98.6
Magnetite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	1.5	15.0	0.4	0.1	41.4	20.7	1.1	18.4	0.1	98.5
Kya/Sill	0.3	0.4	0.3	0.1	42.2	53.8	0.1	0.0	0.6	98.0
Staurolite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.3	0.5	0.1	0.1	27.0	0.2	0.1	0.1	60.5	88.9
Silicate	1.1	4.6	0.2	0.1	75.1	14.4	1.6	0.9	0.1	98.0
Unclassified	7.0	6.9	0.5	1.0	18.4	5.8	1.6	8.3	36.0	85.6

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	83.5	3.2	0.7	3.8	1.2	6.9	0.7	0.0	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	53.9	75.5	92.8	43.7
Fe ₂ O ₃ wt%	40.2	13.5	1.2	44.0
MnO wt%	3.4	1.1	0.3	2.8
Cr ₂ O ₃ wt%	0.1	0.1	0.0	0.1
SiO ₂ wt%	1.1	5.8	3.5	6.7
Al ₂ O ₃ wt%	0.8	3.2	1.8	1.5
MgO wt%	0.2	0.4	0.2	0.3
CaO wt%	0.1	0.2	0.1	0.5
ZrO ₂ wt%	0.1	0.1	0.2	0.5
Total	100.0	100.0	100.0	100.0

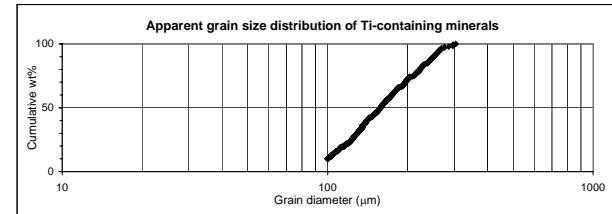
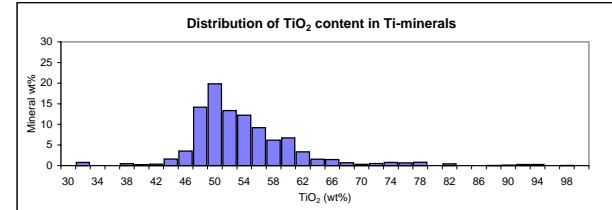
Average TiO ₂ content of all the TiO ₂ minerals:	54.6
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	54.3
Valuable heavy minerals in raw sand:	0.00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	74.2	
Leucoxene	2.9	
Rutile	0.6	
Ti magnetite	3.4	
Magnetite	0.0	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	1.1	
Kya/Sill	0.6	
Staurolite	0.0	
Zircon	6.1	
Silicate	8.1	
Unclassified	3.0	
Total	100.0	

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Lab. Name:	2-389	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/14/2003		



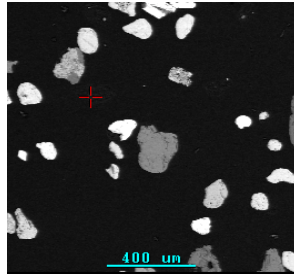
Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	Total grains
Ilmenite	1.6	1.8	538	208	14189	871
Leucoxene	1.3	1.5	460	161	14508	33
Rutile	1.5	1.7	328	120	6506	14
Ti magnetite	1.5	1.8	511	199	12972	41
Magnetite	0.0	0.0	0	0	0	0
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.5	1.8	585	225	18138	11
Kya/Sill	1.8	3.6	1280	573	35935	4
Staurolite	0.0	0.0	0	0	0	0
Zircon	1.5	1.7	453	166	10863	91
Silicate	1.6	2.0	663	262	20795	110
Unclassified	1.7	2.1	606	247	19061	43



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GEUS

Sample Name:	2000390	No. of frames analysed:	64
Lab. Name:	2-390	No. of particles analysed:	2117
Date:	11/14/2003	Heavy minerals in raw sand (%):	0.00
Submitter:	Henrik Stendal	Country:	Vietnam
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	125 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	54.0	38.4	2.9	0.1	2.2	0.9	0.2	0.1	0.1	98.9
Leucoxene	74.3	9.0	0.6	0.1	10.5	3.3	0.3	0.1	0.1	98.5
Rutile	94.5	0.9	0.2	0.1	1.5	0.9	0.1	0.1	0.1	98.5
Ti magnetite	40.9	43.4	2.6	0.2	7.0	2.2	0.4	0.2	1.1	98.0
Magnetite	8.0	80.4	0.4	0.0	4.3	2.7	1.2	0.6	0.4	98.1
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	0.6	14.3	0.2	0.1	39.9	20.9	0.4	21.8	0.4	98.7
Kya/Sill	0.2	1.2	0.2	0.1	42.7	53.5	0.1	0.1	0.5	98.6
Staurolite	1.2	15.9	0.3	0.1	31.5	48.1	1.2	0.1	0.2	98.6
Zircon	0.3	0.4	0.1	0.1	27.0	0.2	0.1	0.1	60.6	88.8
Silicate	3.2	7.5	0.3	0.1	60.3	21.5	3.0	1.8	0.1	97.8
Unclassified	12.5	7.0	0.7	1.1	22.5	11.1	4.6	1.5	24.1	85.1

Valuable heavy minerals							
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Total
wt %	63.0	7.6	3.8	4.6	6.7	13.3	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	54.6	75.5	96.0	41.7
Fe ₂ O ₃ wt%	38.9	9.1	0.9	44.3
MnO wt%	2.9	0.6	0.2	2.7
Cr ₂ O ₃ wt%	0.1	0.1	0.1	0.2
SiO ₂ wt%	2.2	10.7	1.6	7.2
Al ₂ O ₃ wt%	0.9	3.4	0.9	2.3
MgO wt%	0.2	0.3	0.1	0.4
CaO wt%	0.1	0.1	0.1	0.2
ZrO ₂ wt%	0.1	0.1	0.1	1.1
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	57.9
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	55.9
Valuable heavy minerals in raw sand:	0.00

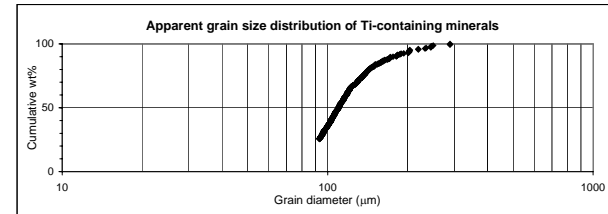
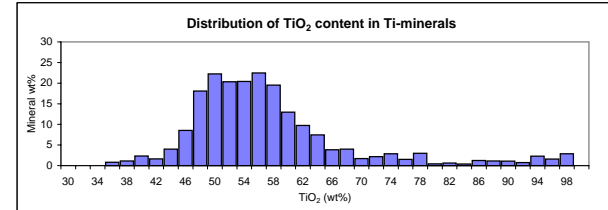
Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	54.0	
Leucoxene	6.6	
Rutile	3.3	
Ti magnetite	3.9	
Magnetite	0.4	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	5.8	
Kya/Sill	0.2	
Staurolite	0.5	
Zircon	11.4	
Silicate	11.4	
Unclassified	2.4	
Total	100.0	

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GEUS

Lab. Name:	2-390	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/14/2003		



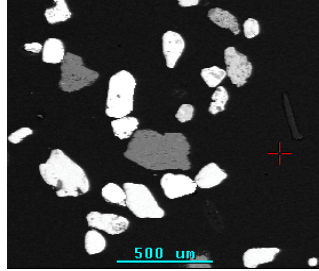
Category	Average grain parameters				Area (µm ²)	Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)		
Ilmenite	1.6	1.7	376	138	7424	1090
Leucoxene	1.6	1.7	464	172	11042	84
Rutile	1.5	1.6	370	134	7422	58
Ti magnetite	1.6	1.8	372	144	7258	76
Magnetite	1.4	1.5	359	125	7590	7
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.6	2.0	538	217	12547	70
Kya/Sill	1.7	2.1	513	206	10495	5
Staurolite	1.3	1.7	421	158	9322	9
Zircon	1.4	1.5	327	115	6035	267
Silicate	1.5	1.9	478	187	11594	240
Unclassified	1.5	1.8	381	151	7845	77



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GEUS

Sample Name:	2000392	No. of frames analysed:	72
Lab. Name:	2-392	No. of particles analysed:	667
Date:	11/26/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	200 µm		
Sieve:	100 µm ²		

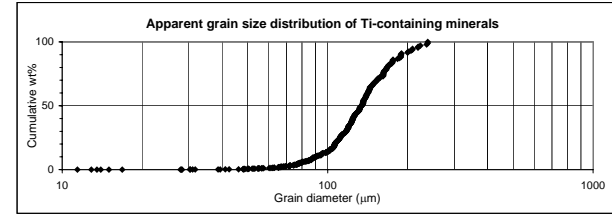
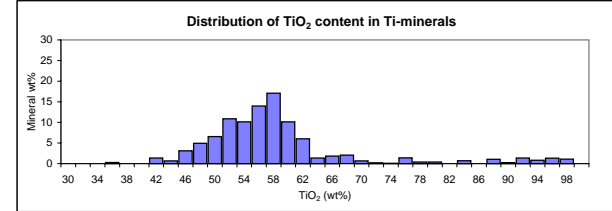


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GEUS

Lab. Name:	2-392	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/26/2003		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	55.4	36.5	2.8	0.1	2.1	1.4	0.3	0.1	0.2	99.0
Leucoxene	75.7	10.1	0.9	0.1	7.8	3.4	0.1	0.1	0.5	98.6
Rutile	93.4	1.5	0.2	0.1	2.0	1.3	0.1	0.1	0.2	98.7
Ti magnetite	43.4	40.9	2.4	0.2	8.6	1.7	0.2	0.1	1.4	98.7
Magnetite	2.8	74.8	0.2	0.0	11.6	6.2	1.7	0.2	0.7	98.3
Chromite	0.3	10.9	0.0	51.2	10.9	11.9	2.4	0.0	0.0	87.7
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	0.6	13.2	0.3	0.1	41.8	21.6	0.5	19.1	1.0	98.3
Kya/Sill	0.3	0.6	0.0	0.1	43.1	54.2	0.1	0.1	0.3	98.9
Staurolite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.2	0.4	0.1	0.1	27.0	0.4	0.1	0.1	60.3	88.6
Silicate	2.9	8.5	0.2	0.1	54.4	26.9	3.1	1.4	0.1	97.5
Unclassified	12.1	5.6	0.3	0.8	28.7	6.8	1.1	2.7	33.0	91.2

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	68.3	3.3	4.6	2.4	3.0	18.0	0.4	0.0	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	56.0	76.8	94.6	43.9
Fe ₂ O ₃ wt%	36.9	10.2	1.5	41.5
MnO wt%	2.9	0.9	0.2	2.4
Cr ₂ O ₃ wt%	0.1	0.1	0.1	0.2
SiO ₂ wt%	2.1	7.9	2.0	8.7
Al ₂ O ₃ wt%	1.5	3.5	1.4	1.7
MgO wt%	0.3	0.1	0.1	0.2
CaO wt%	0.1	0.1	0.1	0.1
ZrO ₂ wt%	0.2	0.5	0.2	1.4
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	58.8
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	56.5
Valuable heavy minerals in raw sand:	0.00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	55.9	
Leucoxene	2.7	
Rutile	3.8	
Ti magnetite	2.0	
Magnetite	0.2	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	2.4	
Kya/Sill	0.3	
Staurolite	0.0	
Zircon	14.7	
Silicate	15.8	
Unclassified	2.2	
Total	100.0	

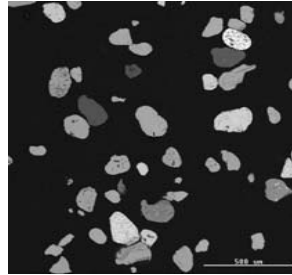
Category	Average grain parameters				Area (µm ²)	Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)		
Ilmenite	1.6	1.8	476	182	11113	359
Leucoxene	1.5	2.2	565	228	12807	15
Rutile	1.5	1.8	450	173	9738	25
Ti magnetite	1.7	2.1	512	208	11021	12
Magnetite	1.5	2.1	388	151	6887	2
Chromite	1.8	1.4	114	37	746	1
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.6	2.2	494	206	12152	16
Kya/Sill	1.4	1.9	597	232	15883	2
Staurolite	0.0	0.0	0	0	0	0
Zircon	1.5	1.7	419	157	9160	111
Silicate	1.5	2.0	633	256	18217	105
Unclassified	1.6	2.1	510	208	13480	19



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Sample Name:	2000395	No. of frames analysed:	19
Lab. Name:	2-395	No. of particles analysed:	800
Date:	11/24/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/100x		
Guard region:	150 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	52.4	40.3	3.1	0.1	1.8	0.9	0.2	0.1	0.1	99.0
Leucoxene	72.6	9.4	0.6	0.0	10.6	4.7	0.2	0.1	0.1	98.5
Rutile	92.2	1.0	0.2	0.0	3.2	1.4	0.1	0.1	0.4	98.6
Ti magnetite	40.4	39.5	2.6	0.1	10.5	3.0	0.6	0.3	1.4	98.4
Magnetite	7.2	82.5	0.2	0.1	4.4	4.1	0.3	0.0	0.1	98.9
Chromite	0.3	21.8	0.3	62.8	1.4	5.7	6.2	0.2	0.0	98.6
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	2.5	15.2	0.7	0.1	38.5	18.9	0.6	13.0	8.0	97.4
Kya/Sill	0.3	1.1	0.2	0.0	42.7	53.6	0.0	0.1	0.1	98.1
Staurolite	0.6	15.0	0.5	0.0	31.8	50.3	0.6	0.0	0.0	98.9
Zircon	0.2	0.3	0.1	0.1	27.0	0.2	0.1	0.1	60.3	88.5
Silicate	3.8	5.7	0.2	0.1	67.0	16.9	2.2	1.4	0.1	97.4
Unclassified	10.1	6.9	0.5	0.3	19.7	10.8	1.3	2.0	27.1	78.6

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	61.5	6.0	3.9	9.2	1.5	17.5	0.4	0.1	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	53.0	73.7	93.5	41.1
Fe ₂ O ₃ wt%	40.7	9.6	1.0	40.1
MnO wt%	3.1	0.7	0.2	2.6
Cr ₂ O ₃ wt%	0.1	0.0	0.0	0.1
SiO ₂ wt%	1.8	10.8	3.2	10.7
Al ₂ O ₃ wt%	0.9	4.8	1.4	3.1
MgO wt%	0.2	0.2	0.1	0.6
CaO wt%	0.1	0.1	0.1	0.3
ZrO ₂ wt%	0.1	0.1	0.4	1.4
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	55.1
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	53.2
Valuable heavy minerals in raw sand:	0.00

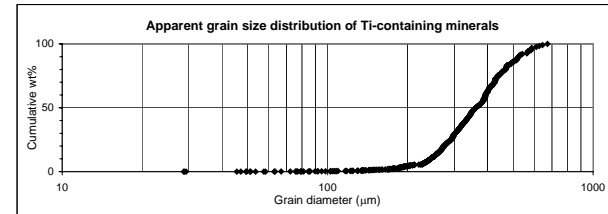
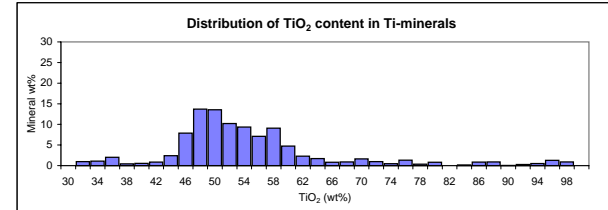
Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	55.1	
Leucoxene	5.4	
Rutile	3.5	
Ti magnetite	8.3	
Magnetite	1.1	
Chromite	0.1	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	1.3	
Kya/Sill	0.3	
Staurolite	0.1	
Zircon	15.6	
Silicate	6.9	
Unclassified	2.5	
Total	100.0	

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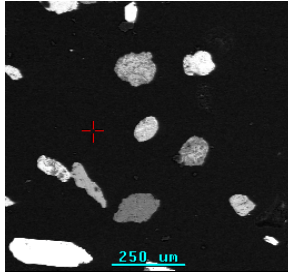
Lab. Name:	2-395	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/24/2003		



Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	
Ilmenite	1.5	1.7	1161	427	72790	453
Leucoxene	1.6	1.9	1554	592	110748	29
Rutile	1.7	1.8	1315	497	82212	23
Ti magnetite	1.6	2.0	1434	577	89582	52
Magnetite	1.7	2.1	1288	519	69470	8
Chromite	1.2	1.6	839	302	35498	1
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.5	1.9	1389	568	98953	9
Kya/Sill	1.2	1.8	1404	532	90925	3
Staurolite	1.6	1.7	930	346	41136	1
Zircon	1.4	1.6	1139	415	74956	121
Silicate	1.5	1.9	1420	560	99654	70
Unclassified	1.5	1.8	1223	500	81697	30



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Sample Name:	2000396	No. of frames analysed:	81
Lab. Name:	2-396	No. of particles analysed:	1195
Date:	11/13/2003	Heavy minerals in raw	
Submitter:	Henrik Stendal	sand (%):	0.00
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	150 µm		
Sieve:	100 µm ²		

Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	53.2	38.9	3.2	0.1	2.1	1.1	0.2	0.1	0.1	99.0
Leucoxene	75.8	8.9	0.8	0.1	8.4	4.2	0.3	0.1	0.1	98.7
Rutile	94.1	0.9	0.2	0.0	2.1	1.2	0.1	0.1	0.2	98.7
Ti magnetite	42.0	39.1	3.5	0.1	10.2	2.6	0.6	0.1	0.4	98.5
Magnetite	5.1	76.7	0.2	0.3	13.6	2.6	0.2	0.0	0.0	98.7
Chromite	0.0	17.5	0.0	59.6	0.5	11.7	7.5	0.0	0.0	96.9
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	6.3	14.1	0.5	0.3	39.7	19.9	1.3	15.6	0.2	97.8
Kya/Sill	0.2	0.8	0.1	0.2	42.9	54.0	0.0	0.0	0.1	98.4
Staurolite	0.4	15.1	0.2	0.3	33.0	47.2	1.2	0.0	0.0	97.4
Zircon	0.3	0.4	0.1	0.1	27.0	0.2	0.1	0.1	60.8	89.1
Silicate	2.5	7.0	0.2	0.1	62.5	21.5	2.2	1.3	0.2	97.4
Unclassified	14.8	6.2	1.7	0.3	24.1	7.6	1.1	4.7	16.3	76.7

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	66.6	5.4	3.1	5.3	2.1	17.1	0.5	0.0	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	53.8	76.9	95.3	42.6
Fe ₂ O ₃ wt%	39.3	9.0	0.9	39.7
MnO wt%	3.2	0.8	0.2	3.5
Cr ₂ O ₃ wt%	0.1	0.1	0.0	0.1
SiO ₂ wt%	2.1	8.5	2.1	10.3
Al ₂ O ₃ wt%	1.1	4.2	1.2	2.6
MgO wt%	0.2	0.3	0.1	0.6
CaO wt%	0.1	0.1	0.1	0.1
ZrO ₂ wt%	0.1	0.1	0.2	0.4
Total	100.0	100.0	100.0	100.0

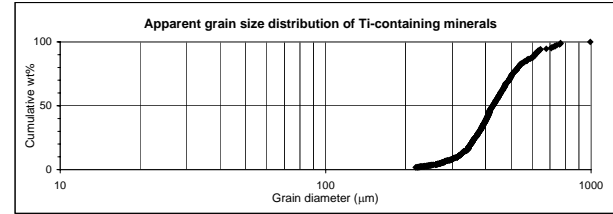
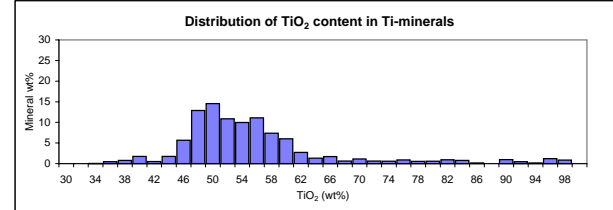
Average TiO ₂ content of all the TiO ₂ minerals:	56.2
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	54.6
Valuable heavy minerals in raw sand:	0.00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	57.1	
Leucoxene	4.6	
Rutile	2.7	
Ti magnetite	4.5	
Magnetite	0.4	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	1.8	
Kya/Sill	0.4	
Staurolite	0.0	
Zircon	14.6	
Silicate	10.6	
Unclassified	3.2	
Total	100.0	

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Lab. Name:	2-396	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/13/2003		



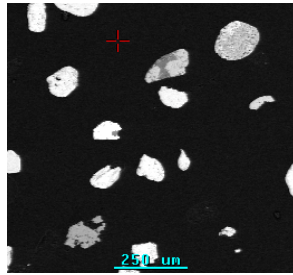
Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	
Ilmenite	1.6	1.8	1572	605	117406	614
Leucoxene	1.6	1.9	1709	663	138341	42
Rutile	1.5	1.9	1618	634	120979	25
Ti magnetite	1.8	2.0	1583	626	109355	49
Magnetite	1.6	2.2	1287	530	66488	6
Chromite	1.4	1.4	759	247	32756	1
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.5	1.8	1572	631	129622	20
Kya/Sill	1.8	1.9	1737	682	141282	5
Staurolite	2.3	2.4	748	319	20484	2
Zircon	1.4	1.7	1441	536	109073	164
Silicate	1.6	2.0	1507	613	115355	198
Unclassified	1.5	1.8	1314	525	98583	69



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Sample Name: 2000400	No. of frames analysed: 46
Lab. Name: 2-400	No. of particles analysed: 802
Date: 11/11/2003	Heavy minerals in raw
Submitter: Henrik Stendal	sand (%): 0.00
Country: Vietnam	Comments:
Analysed by: DF	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: 150 µm	
Sieve: 100 µm ²	



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	54.4	38.6	2.9	0.1	1.5	0.8	0.3	0.1	0.2	98.9
Leucoxene	74.7	10.6	1.0	0.1	8.0	3.4	0.3	0.1	0.1	98.5
Rutile	91.9	1.5	0.1	0.1	3.5	1.5	0.1	0.1	0.1	98.8
Ti magnetite	43.1	41.9	3.3	0.1	7.2	2.1	0.4	0.1	0.8	99.0
Magnetite	5.2	80.1	0.5	0.7	4.2	3.2	0.4	0.0	0.2	94.5
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	9.1	12.0	2.1	0.1	38.9	18.9	1.0	15.8	0.1	98.0
Kya/Sill	0.3	1.1	0.2	0.3	42.3	54.3	0.1	0.1	0.4	99.1
Staurolite	0.7	18.0	0.4	0.1	31.9	46.0	1.6	0.2	0.3	99.2
Zircon	0.3	0.4	0.2	0.1	27.1	0.1	0.1	0.1	60.9	89.3
Silicate	2.2	5.9	0.2	0.1	71.4	14.1	1.9	1.1	0.1	97.2
Unclassified	17.9	7.5	1.5	1.0	26.5	16.6	2.6	6.0	8.0	87.7

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	75.7	7.3	3.9	3.3	2.1	7.2	0.3	0.1	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	55.0	75.8	93.0	43.5
Fe ₂ O ₃ wt%	39.1	10.8	1.5	42.4
MnO wt%	3.0	1.0	0.1	3.3
Cr ₂ O ₃ wt%	0.1	0.1	0.1	0.1
SiO ₂ wt%	1.5	8.2	3.5	7.2
Al ₂ O ₃ wt%	0.8	3.5	1.5	2.2
MgO wt%	0.3	0.3	0.1	0.4
CaO wt%	0.1	0.1	0.1	0.1
ZrO ₂ wt%	0.2	0.1	0.1	0.8
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	58.0
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	56.4
Valuable heavy minerals in raw sand:	0.00

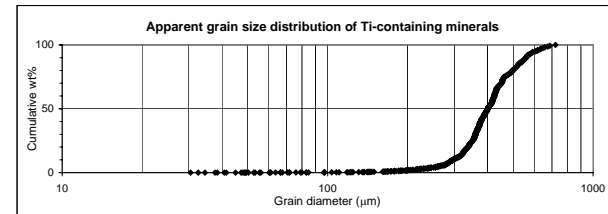
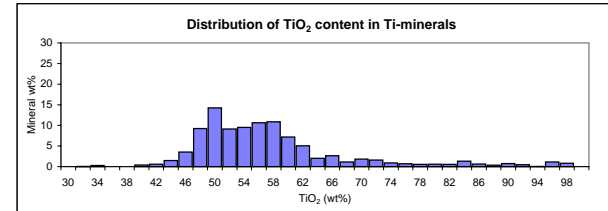
Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand wt %
Ilmenite	62.4	
Leucoxene	6.0	
Rutile	3.3	
Ti magnetite	2.7	
Magnetite	0.5	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	1.7	
Kya/Sill	0.3	
Staurolite	0.1	
Zircon	6.0	
Silicate	15.2	
Unclassified	1.9	
Total	100.0	

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GEUS

Lab. Name: 2-400	Analyzed by: DF
Submitter: Henrik Stendal	Acc. Voltage: 17kV
Date: 11/11/2003	



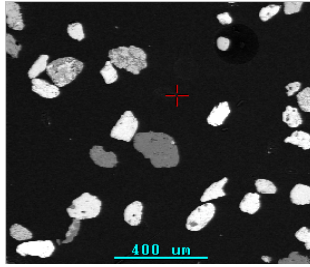
Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	
Ilmenite	1.6	1.8	1433	548	100954	504
Leucoxene	1.6	2.0	1680	667	122335	40
Rutile	1.5	1.7	1388	521	99411	24
Ti magnetite	1.6	2.0	1438	567	94741	22
Magnetite	1.4	1.5	1125	397	79455	4
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	0.0	0.0	0	0	0	0
Garnet	1.6	2.0	1419	578	97733	16
Kya/Sill	1.3	1.9	1206	493	75999	4
Staurolite	1.8	2.7	1949	840	113177	1
Zircon	1.5	1.8	1305	494	82709	57
Silicate	1.6	2.1	2130	875	205916	102
Unclassified	1.5	1.7	1247	494	94261	28



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GEUS

Sample Name:	2000651	No. of frames analysed:	81
Lab. Name:	2-651	No. of particles analysed:	1800
Date:	11/26/2003	Heavy minerals in raw sand (%):	0.00
Submitter:	Henrik Stendal	Country:	Vietnam
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	125 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	54.5	37.3	3.0	0.1	2.4	1.1	0.2	0.1	0.2	99.0
Leucoxene	75.5	8.5	0.5	0.1	9.7	3.3	0.3	0.1	0.4	98.5
Rutile	92.3	1.9	0.3	0.0	2.3	1.3	0.2	0.1	0.1	98.6
Ti magnetite	42.4	41.6	2.8	0.1	7.6	2.4	0.7	0.2	0.5	98.3
Magnetite	2.9	70.7	0.9	0.3	15.5	5.9	0.9	0.2	1.0	98.2
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	36.6	1.1	0.2	0.0	29.5	4.2	0.1	27.6	0.0	99.2
Garnet	1.6	14.0	0.3	0.2	40.3	21.2	1.9	18.6	0.1	98.2
Kya/Sill	0.5	1.0	0.1	0.0	42.7	54.1	0.0	0.0	0.2	98.8
Staurolite	0.3	15.2	0.1	0.2	32.4	49.4	0.9	0.0	0.0	98.6
Zircon	0.3	0.3	0.1	0.1	26.9	0.2	0.1	0.1	60.4	88.5
Silicate	2.0	6.3	0.2	0.1	68.7	15.6	2.8	1.8	0.1	97.7
Unclassified	12.2	6.0	0.6	0.3	23.1	14.8	1.4	1.3	25.0	84.7

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	68.7	8.4	4.9	4.6	4.5	8.4	0.4	0.1	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	55.1	76.6	93.6	43.1
Fe ₂ O ₃ wt%	37.7	8.6	2.0	42.4
MnO wt%	3.0	0.6	0.3	2.8
Cr ₂ O ₃ wt%	0.1	0.1	0.0	0.1
SiO ₂ wt%	2.5	9.9	2.4	7.8
Al ₂ O ₃ wt%	1.1	3.3	1.3	2.4
MgO wt%	0.2	0.3	0.2	0.8
CaO wt%	0.1	0.1	0.1	0.2
ZrO ₂ wt%	0.2	0.4	0.1	0.5
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	58.7
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	56.6
Valuable heavy minerals in raw sand:	0.00

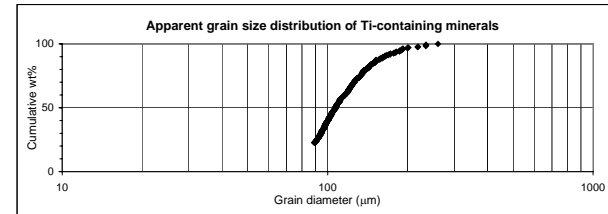
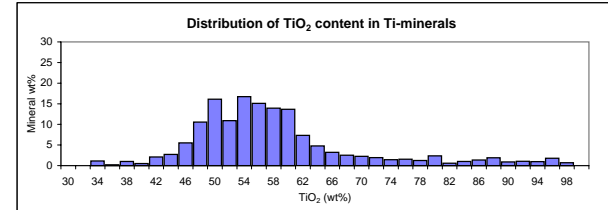
Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand
Ilmenite	55.5	
Leucoxene	6.8	
Rutile	4.0	
Ti magnetite	3.7	
Magnetite	0.2	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.0	
Garnet	3.6	
Kya/Sill	0.3	
Staurolite	0.1	
Zircon	6.8	
Silicate	14.8	
Unclassified	4.1	
Total	100.0	

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GEUS

Lab. Name:	2-651	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/26/2003		



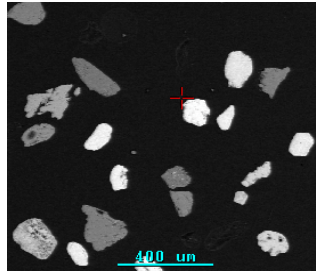
Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	Total grains
Ilmenite	1.6	1.8	383	148	7031	1012
Leucoxene	1.5	1.9	448	172	9501	91
Rutile	1.6	1.8	353	136	6538	73
Ti magnetite	1.6	2.0	427	173	7755	59
Magnetite	1.6	1.5	231	79	3617	5
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	1.3	1.6	350	129	5923	1
Garnet	1.5	2.1	520	215	11620	48
Kya/Sill	1.4	2.4	569	236	11326	5
Staurolite	1.4	1.9	480	187	9876	1
Zircon	1.5	1.6	304	108	5106	166
Silicate	1.5	2.1	529	216	12597	258
Unclassified	1.6	2.3	533	226	11422	81



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GEUS

Sample Name:	2000652	No. of frames analysed:	81
Lab. Name:	2-652	No. of particles analysed:	1180
Date:	11/26/2003	Heavy minerals in raw sand (%):	0.00
Submitter:	Henrik Stendal	Country:	Vietnam
Country:	Vietnam	Comments:	
Analyzed by:	DF		
Acc. Voltage/Magnification:	17kV/100x		
Guard region:	150 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	56.9	34.1	2.4	0.1	3.5	1.3	0.3	0.1	0.2	98.9
Leucoxene	75.1	10.2	0.6	0.2	8.3	3.9	0.3	0.1	0.2	98.7
Rutile	93.1	1.0	0.2	0.0	2.8	1.2	0.1	0.1	0.1	98.7
Ti magnetite	38.7	31.2	2.8	0.1	17.9	2.8	0.4	0.1	3.4	97.3
Magnetite	1.2	67.7	0.0	0.1	18.1	10.1	0.4	0.1	0.8	98.6
Chromite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y-phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphene	49.3	1.0	0.3	0.0	23.5	4.2	0.0	21.3	0.0	99.7
Garnet	1.3	15.2	0.3	0.1	40.9	20.5	0.6	20.1	0.0	98.9
Kya/Sill	0.1	0.8	0.1	0.0	42.9	54.2	0.0	0.0	0.3	98.4
Staurolite	2.1	12.5	0.3	0.2	37.1	45.2	0.9	0.1	0.0	98.4
Zircon	0.2	0.5	0.1	0.1	27.0	0.2	0.1	0.1	60.2	88.5
Silicate	3.5	8.6	0.2	0.1	57.3	22.1	3.4	2.3	0.1	97.7
Unclassified	21.6	9.3	2.2	0.7	33.4	13.0	1.2	1.5	10.8	93.7

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	56.7	17.3	6.2	2.4	7.3	9.2	0.6	0.3	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	57.5	76.0	94.3	39.7
Fe ₂ O ₃ wt%	34.5	10.3	1.0	32.1
MnO wt%	2.4	0.6	0.2	2.9
Cr ₂ O ₃ wt%	0.1	0.2	0.1	0.1
SiO ₂ wt%	3.6	8.4	2.9	18.4
Al ₂ O ₃ wt%	1.3	3.9	1.2	2.8
MgO wt%	0.3	0.3	0.1	0.4
CaO wt%	0.1	0.1	0.1	0.1
ZrO ₂ wt%	0.2	0.2	0.1	3.5
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	63.7
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	61.2
Valuable heavy minerals in raw sand:	0.00

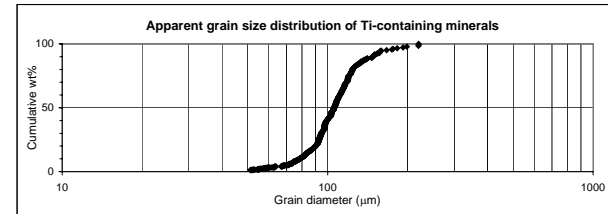
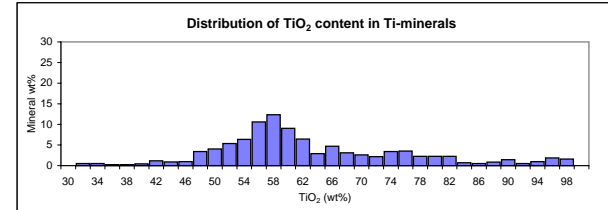
Weight percent on a mineral basis:		
Category	Heavy mineral concentrate	
	wt %	Raw sand wt %
Ilmenite	42.8	
Leucoxene	13.1	
Rutile	4.7	
Ti magnetite	1.8	
Magnetite	0.4	
Chromite	0.0	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.0	
Y-phosphate	0.0	
Sphene	0.3	
Garnet	5.5	
Kya/Sill	0.5	
Staurolite	0.2	
Zircon	7.0	
Silicate	20.2	
Unclassified	3.6	
Total	100.0	

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GEUS

Lab. Name:	2-652	Analyzed by:	DF
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	11/26/2003		



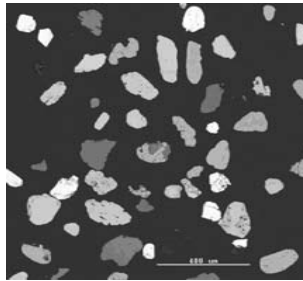
Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm ²)	
Ilmenite	1.6	1.7	368	139	6750	532
Leucoxene	1.7	1.9	437	169	8984	122
Rutile	1.5	1.9	378	146	6978	51
Ti magnetite	1.5	2.0	458	188	9389	15
Magnetite	1.9	2.1	611	242	15810	2
Chromite	0.0	0.0	0	0	0	0
Pyrite	0.0	0.0	0	0	0	0
Phosphate	0.0	0.0	0	0	0	0
Monazite	0.0	0.0	0	0	0	0
Y-phosphate	0.0	0.0	0	0	0	0
Sphene	1.4	2.2	883	364	28109	1
Garnet	1.5	2.1	549	219	12730	41
Kya/Sill	1.7	2.4	550	231	10903	5
Staurolite	1.3	2.0	286	114	3825	5
Zircon	1.5	1.7	346	128	6140	92
Silicate	1.6	2.0	487	197	10990	261
Unclassified	1.6	2.0	430	174	9434	53



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GEUS

Sample Name:	2000665	No. of frames analysed:	34
Lab. Name:	VN47	No. of particles analysed:	657
Date:	6/16/2003	Heavy minerals in raw sand (%):	0.00
Submitter:	Henrik Stendal	Country:	Vietnam
Country:	Vietnam	Comments:	
Analyzed by:	JK		
Acc. Voltage/Magnification:	17kV/75x		
Guard region:	175 µm		
Sieve:	100 µm ²		



Average content										
Category	TiO ₂ wt%	Fe ₂ O ₃ wt%	MnO wt%	Cr ₂ O ₃ wt%	SiO ₂ wt%	Al ₂ O ₃ wt%	MgO wt%	CaO wt%	ZrO ₂ wt%	Total
Ilmenite	61.6	31.1	2.8	0.1	1.6	0.9	0.1	0.0	0.4	98.8
Leucoxene	76.6	15.0	1.1	0.1	3.7	1.5	0.1	0.1	0.3	98.4
Rutile	93.4	1.6	0.1	0.1	2.2	0.9	0.1	0.1	0.2	98.6
Ti magnetite	39.2	27.0	0.8	0.0	19.3	9.4	1.4	0.2	0.2	97.5
Magnetite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chromite	1.1	24.8	0.9	49.3	0.4	16.0	5.9	0.2	0.3	98.8
Pyrite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monazite	0.0	0.0	0.0	0.0	4.8	1.5	0.2	1.4	6.5	14.4
Y-phosphate	0.4	3.5	0.0	0.0	1.6	0.9	0.1	1.3	4.7	12.5
Sphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garnet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kya/Sill	0.2	0.4	0.2	0.1	42.8	53.8	0.0	0.1	0.3	97.7
Staurolite	0.8	14.5	0.3	0.1	33.0	48.2	1.1	0.0	0.0	98.0
Zircon	0.4	0.3	0.1	0.1	29.9	0.1	0.1	0.1	65.1	96.1
Silicate	2.9	8.0	0.1	0.1	51.2	29.9	3.6	0.6	0.2	96.6
Unclassified	11.8	6.4	1.2	0.2	10.0	43.9	5.8	0.0	13.9	93.3

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	44.6	14.1	21.7	0.7	0.0	16.3	1.2	1.3	100.0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO ₂ wt%	62.3	77.8	94.8	40.2
Fe ₂ O ₃ wt%	31.5	15.2	1.6	27.7
MnO wt%	2.9	1.1	0.1	0.8
Cr ₂ O ₃ wt%	0.1	0.1	0.1	0.0
SiO ₂ wt%	1.7	3.7	2.2	19.8
Al ₂ O ₃ wt%	0.9	1.5	0.9	9.6
MgO wt%	0.1	0.1	0.1	1.4
CaO wt%	0.1	0.1	0.1	0.2
ZrO ₂ wt%	0.5	0.3	0.2	0.2
Total	100.0	100.0	100.0	100.0

Average TiO ₂ content of all the TiO ₂ minerals:	73.5
Average TiO ₂ content of all the TiO ₂ minerals excl. rutile:	65.8
Valuable heavy minerals in raw sand:	53.54

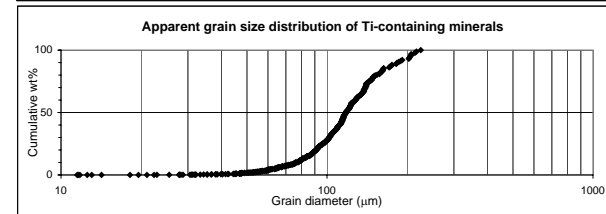
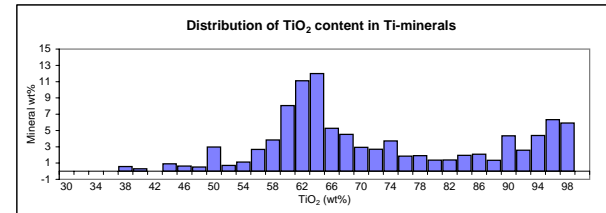
Weight percent on a mineral basis:		
Category	Heavy mineral	
	concentrate	Raw sand
Ilmenite	39.6	
Leucoxene	12.5	
Rutile	19.3	
Ti magnetite	0.6	
Magnetite	0.0	
Chromite	0.5	
Pyrite	0.0	
Phosphate	0.0	
Monazite	0.4	
Y-phosphate	0.1	
Sphene	0.0	
Garnet	0.0	
Kya/Sill	1.1	
Staurolite	1.1	
Zircon	14.5	
Silicate	7.8	
Unclassified	2.5	
Total	100.0	

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GEUS

Lab. Name:	VN47	Analyzed by:	JK
Submitter:	Henrik Stendal	Acc. Voltage:	17kV
Date:	6/16/2003		



Category	Average grain parameters				Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	
Ilmenite	1.6	1.8	393	149	7913
Leucoxene	1.5	1.8	394	150	7929
Rutile	1.6	1.8	412	159	8600
Ti magnetite	1.4	2.3	656	275	15022
Magnetite	0.0	0.0	0	0	0
Chromite	1.8	1.9	341	133	5859
Pyrite	0.0	0.0	0	0	0
Phosphate	0.0	0.0	0	0	0
Monazite	1.5	1.8	321	124	4744
Y-phosphate	1.4	1.6	234	86	2672
Sphene	0.0	0.0	0	0	0
Garnet	0.0	0.0	0	0	0
Kya/Sill	1.9	2.1	530	211	14961
Staurolite	1.7	2.0	381	155	6789
Zircon	1.5	1.6	323	117	5716
Silicate	1.5	1.8	451	176	12834
Unclassified	1.5	2.2	494	208	10904