DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2003/100

Ilmenite heavy sand deposits, South India – provenance and chemistry clues to their origin

Stefan Bernstein

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF THE ENVIRONMENT

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Contents

Abstract

Sediment samples from beaches, rivers and onshore reworked marine sediments (Teri Sands) from the coastal regions of Kerala and Tamil Nadu states, South India, have been analysed by CCSEM in order to place constraints on the genesis of leached ilmenite (pseudorutile) in general and, more specifically, the Chavara heavy mineral deposit in Kerala State. The distribution of ilmenite compositions in terms of TiO_2 shows that samples with elevated TiO_2 in average ilmenite contain few grains of low-TiO_2 ilmenite, while samples with low TiO_2 in average ilmenite contain few grains, if any, with high TiO_2. It is argued that the proximity of samples with high and low TiO_2 in average ilmenite points to a relatively local source of the ilmenite at a length scale of some tens of kilometers, or, alternatively, that the transport of sediment to the site of the heavy mineral deposits must be highly focussed.

Ilmenite from beach sediments that have high average TiO_2 also have elevated MgO (0.8-1.0 wt. %) contrary to ilmenite from beach sediments with low TiO_2, which have MgO of between 0.4 and 0.75 wt. %. A set of river samples with low TiO_2 also have high MgO (0.8-0.95 wt. %) in average ilmenite, which makes it difficult to explain this feature as a result of the leaching process that enhanced the TiO_2. It is thus inferred that the high MgO of ilmenite is an inherited compositional feature. Garnets from samples with high TiO_2 ilmenite are dinstict in having very low grossular and relatively high pyrope components. The river sediment samples containing high MgO ilmenite contain similar low grossular - high pyrope garnets. These observations suggests a strong link between the source of the river sediments and the source of the heavy mineral deposits with high TiO_2 ilmenite in the beaches of the Kerala coast. This common source, unique for the hinterland of the Chevara deposits is most likely the khondalite belt of south India, which contains granulite facies silimanite-garnet shists. An earlier study by Soman (1985) provide evidence that in these rocks, ilmenite is produced by reaction of Ti-bearing biotite to form silimanite + ilmenite. Additional support for this viewpoint comes from the heavy mineral assemblage of the sediment samples, which shows that silimanite-bearing samples are largely confined to the regions with drainage systems originating in the khondalite belt.

A more detailed study of the Chavara segment of the Kerala beach, based on a series of traverses perpendicular tothe coast line and distributed over some 50km along the coast, demonstrates and confirms the high degree of homogeneity of the Chavara deposit as shown by the work of Ramakrishnan et al. (1997) on similar traverses of the Chavara deposits. It also confirms a possible secondary source of the sediment to be the shallow marine sediments off shore the Kerala coast, and that Ti enhancement processes for ilmenite probably are still active in the lagoonal facies of the Kerala coast. The Chavara deposits of high Ti ilmenite can thus be characterized in terms of erosion of a primary source rock consisting of meta-sediments in granulite facies, with silimanite as a key indicator of an ilmenite-forming reaction, followed by transport to a sedimentary basin in a tropical and humid climate. The sedimentary packages were in turn was subjected to reworking in shallow marine environment through fluctuating transgressions and regressions, which served to enhance the heavy mineral fractions in the sediments.

Introduction

Ilmenite is a widespread accessory mineral in nearly all basement lithologies of southern India, and ilmenite is an important constituent of the heavy-mineral fraction in beach and river sediments. However, within the relatively restricted geographical area of southern India, the composition of ilmenite in detrital sediments show large variation in terms of titanium contents. In some areas, the TiO_2 of average ilmenite is high enough to be mined, and indeed, some stretches of the coast line in south Kerala State form world-class heavy mineral deposits, e. .g the Chavara and Manavalakurichi. In other beach sediment occurrences along the coast, the TiO_2 content of the average ilmenite is about the stoichiometric value of 52.5 wt.% or less.

The present project in South India was initiated in 2002 with the aim of determining new areas with occurrences of ilmenite with elevated Ti contents and to contribute to the understanding of processes responsible for the Ti enhancement of ilmenite in detrital sediments (Stendal et al., 2003). In 2002, some 67 samples were collected from the west and east coasts of Kerala State and the southeast coast of Tamil Nadu state (Fig. 1). Samples were collected from rocks (22 samples), and sediments (45 samples) from rivers, beaches and from the socalled Teri Sands, which is an occurrence along the southeast Tamil Nadu coast of red-coloured marine sediments, reworked by aeolian processes (see Stendal et al., 2003 for references). The heavy mineral fraction from 21 samples of beach, river and Teri Sand sediments were run by CC-SEM in 2002 and the results reported in Stendal et al. (2003). In addition, heavy mineral fractions from 8 samples, all beach sediments, were run by CC-SEM in 2003, so this report is mainly based on the CC-SEM data on some 29 samples. All 45 sediment samples were analysed by whole-rock XRF on powder pellets at the Geological Institute, University of Copenhagen.

In addition to the samples collected in 2002, additional 61 samples were collected from the Chavara deposit and surroundings in the spring 2003 (see attached report by Srinivasan and Vasudev, appendix 1). The samples all come from the beach and lagoons around the towns of Quilon and Chavara and cover the coast from sample #29 to #26 of the samples collected in 2002 (see Fig. 1). These data will be reported and referred to in the below section *Local variation within the Quilon-Chavara region.*

The reports of all CCSEM data collected in 2003 are presented in appendix 2 and a summary sheet is given in Table 1, appendix 3.

Samples for ilmenite geochemistry, South India.
(all samples numbers are GEUS #20002xx)

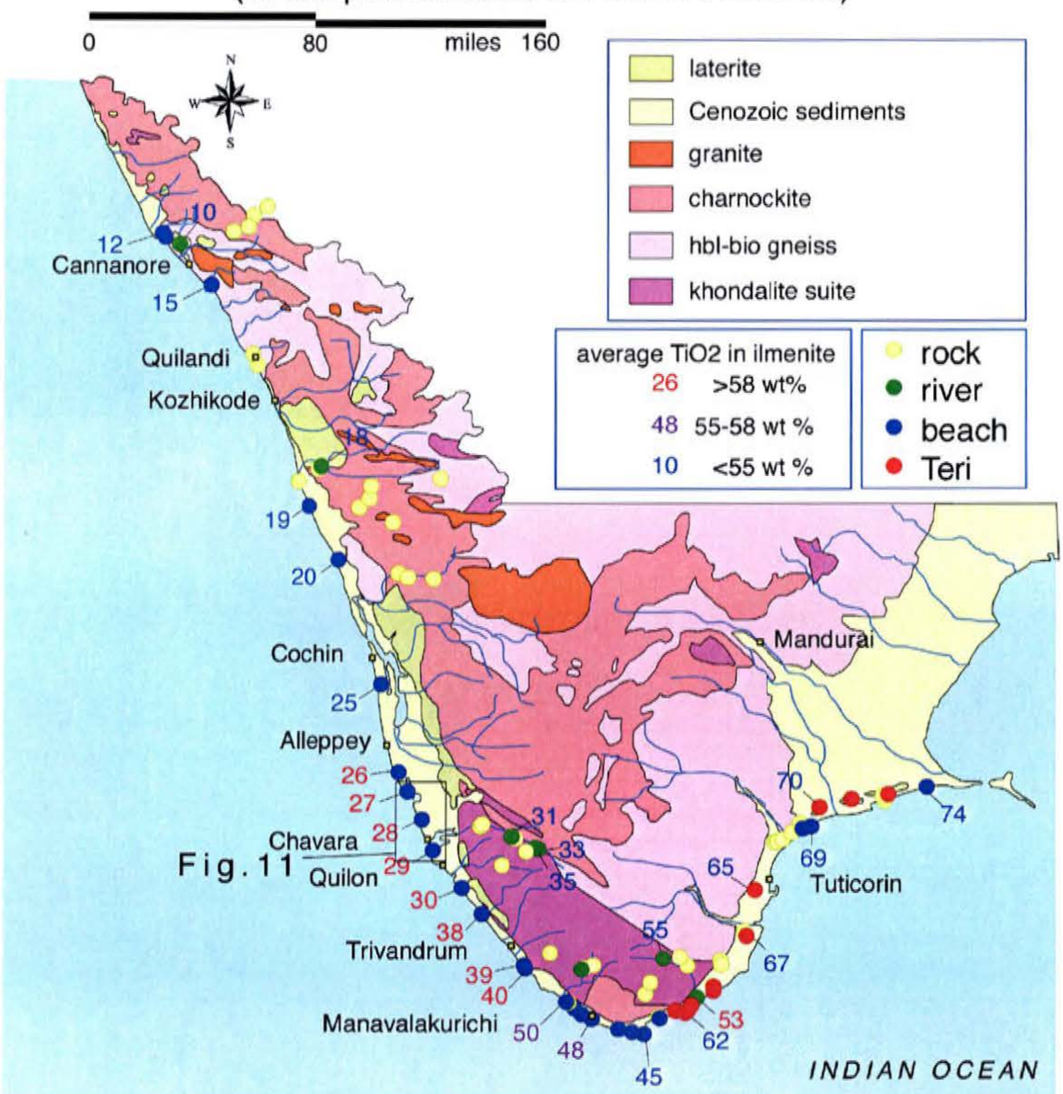


Figure 1.

Sample preparation

All sediment samples were processed as follows: depending on the visual contents of heavy minerals, 30 to 90 grammes of sediment was split from the bulk, dried and washed on a 45 micrometer sieve. The fraction larger than 45 micrometer was then sieved through 710 micrometer screen and the fraction between 45 and 710 micrometer was passed through a centrifuge with $CHBr_3$ with a density of 2.8 gr/cc. The heavy mineral fraction was then mounted in epoxy and polished for SEM analysis. All fractions are weighted.

For bulk XRF analysis, a 30 grammes split was crushed in tungsten-carbide mortar. About 2 grammes of the powder was pressed into pellets and run by a Phillips PW1400 XRF spectrometer at the Geological Institute, University of Copenhagen. The reported major element analyses have been calibrated against a series of sediment samples run by the major element XRF laboratory at GEUS on fused glass discs.

Results and discussion

Distribution of ilmenite compositions in terms of TiO_2 in individual samples

The TiO_2 values of individual ilmenite analyses are shown against the average TiO2 for each sample in Fig. 2.

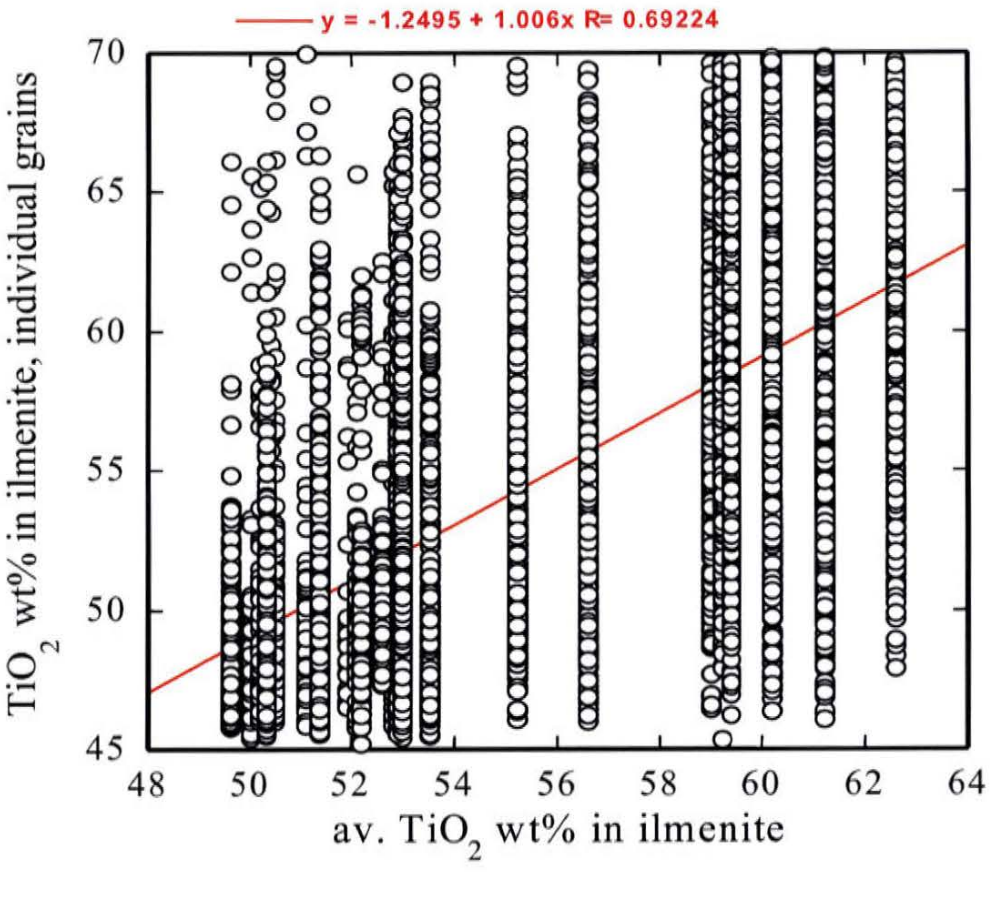
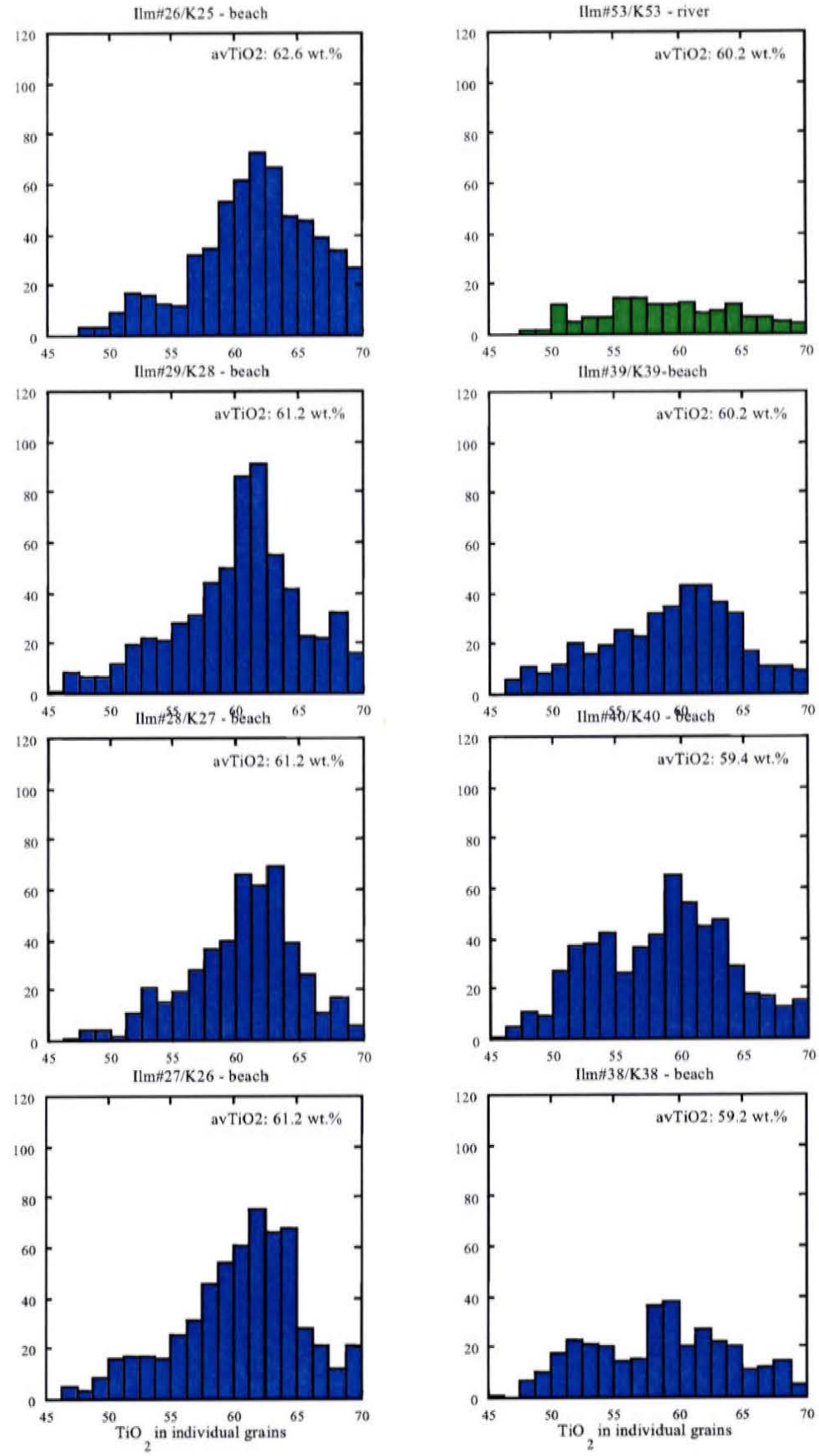


Figure 2

It appears that most of the 29 analysed samples contain ilmenite with TiO_2 contents that span most of the range as defined by all samples (TiO_2 of 45 to 70 wt.%). A more careful study of the distribution of ilmenite compositions within individual samples, reveals that samples with low average TiO_2 in ilmenite have very few grains with high TiO_2, and, similarly, samples with high average TiO_2 in ilmenite posess few grains of low-TiO_2 ilmenite. This is illustrated in a qualitative way in the histograms of ilmenite composition in individual samples (Fig. 3).



Ilm#26/K25 - beach
avTiO2: 62.6 wt.%
Ilm#53/K53 - river
avTiO2: 60.2 wt.%
Ilm#29/K28 - beach
avTiO2: 61.2 wt.%
Ilm#39/K39-beach
avTiO2: 60.2 wt.%
Ilm#28/K27 - beach
avTiO2: 61.2 wt.%
Ilm#40/K40 - beach
avTiO2: 59.4 wt.%
Ilm#27/K26 - beach
avTiO2: 61.2 wt.%
Ilm#38/K38 - beach
avTiO2: 59.2 wt.%
TiO2 in individual grains
TiO2 in individual grains

Figure 3

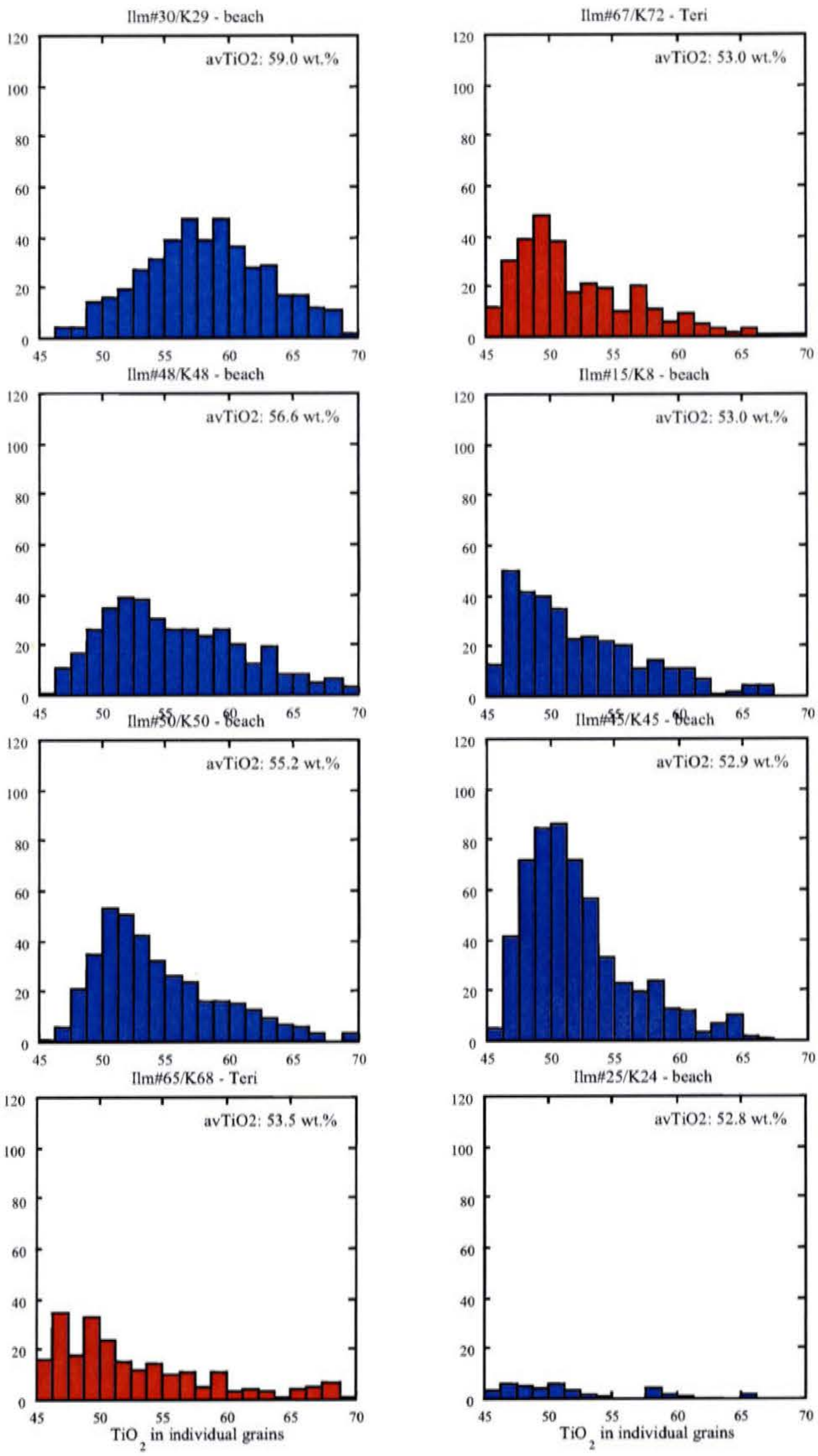


Figure 3, cont.

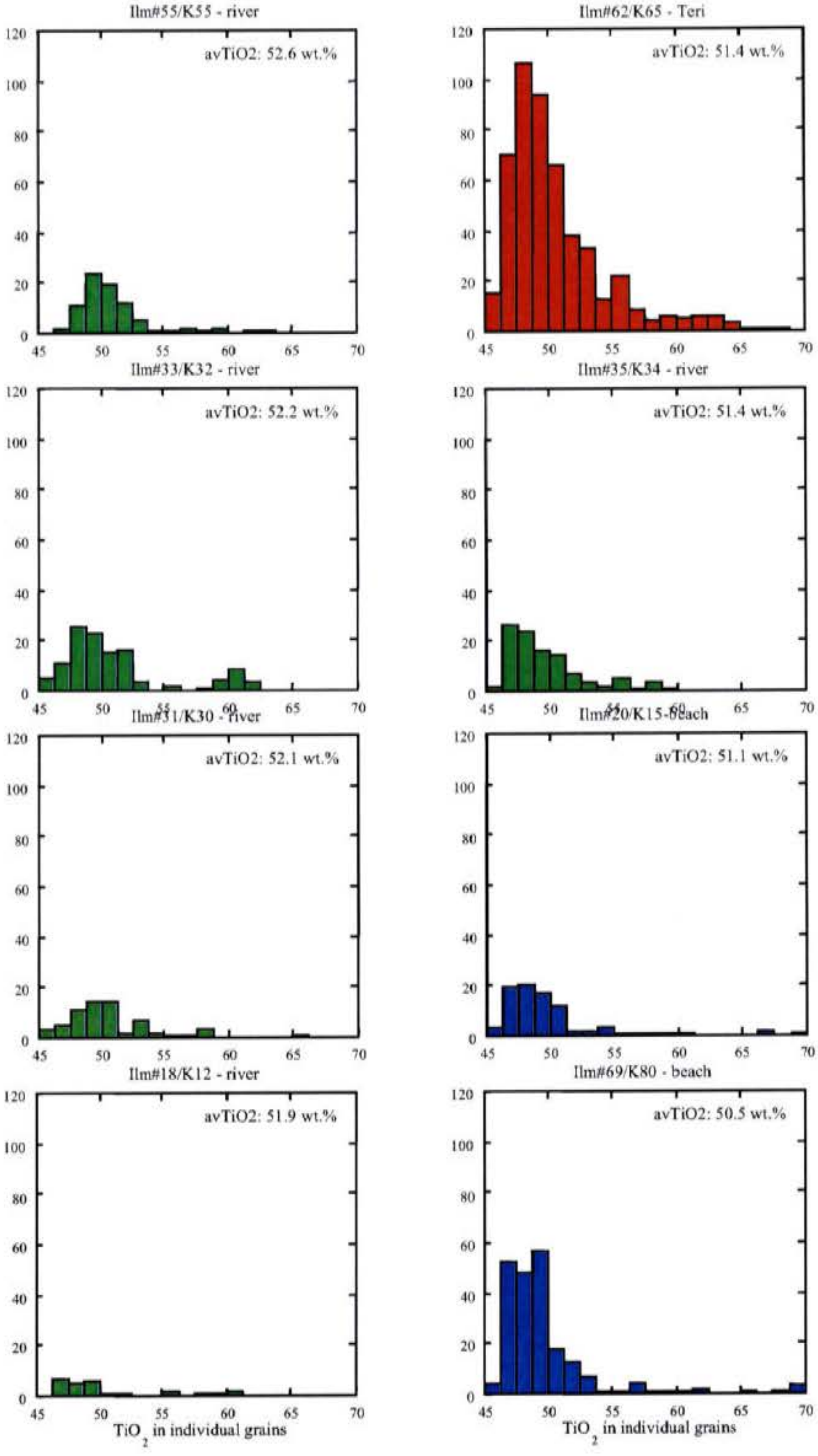


Figure 3, cont.

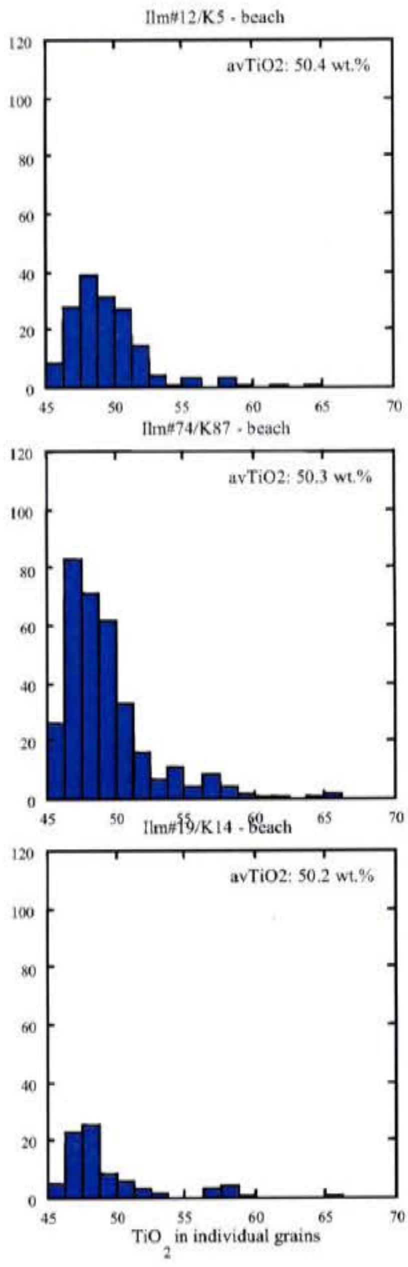


Figure 3, cont.

In order to illustrate this in a more quantitive way, the data for each sample has been divided into two categories. One with a percentage of analyses with ilmenite TiO_2 contents *higher* than average ilmenite TiO_2 + 5 wt.% and one group with a percentage of analyses with ilmenite TiO_2 contents *lower* than average ilmenite TiO_2 + 5 wt.%.

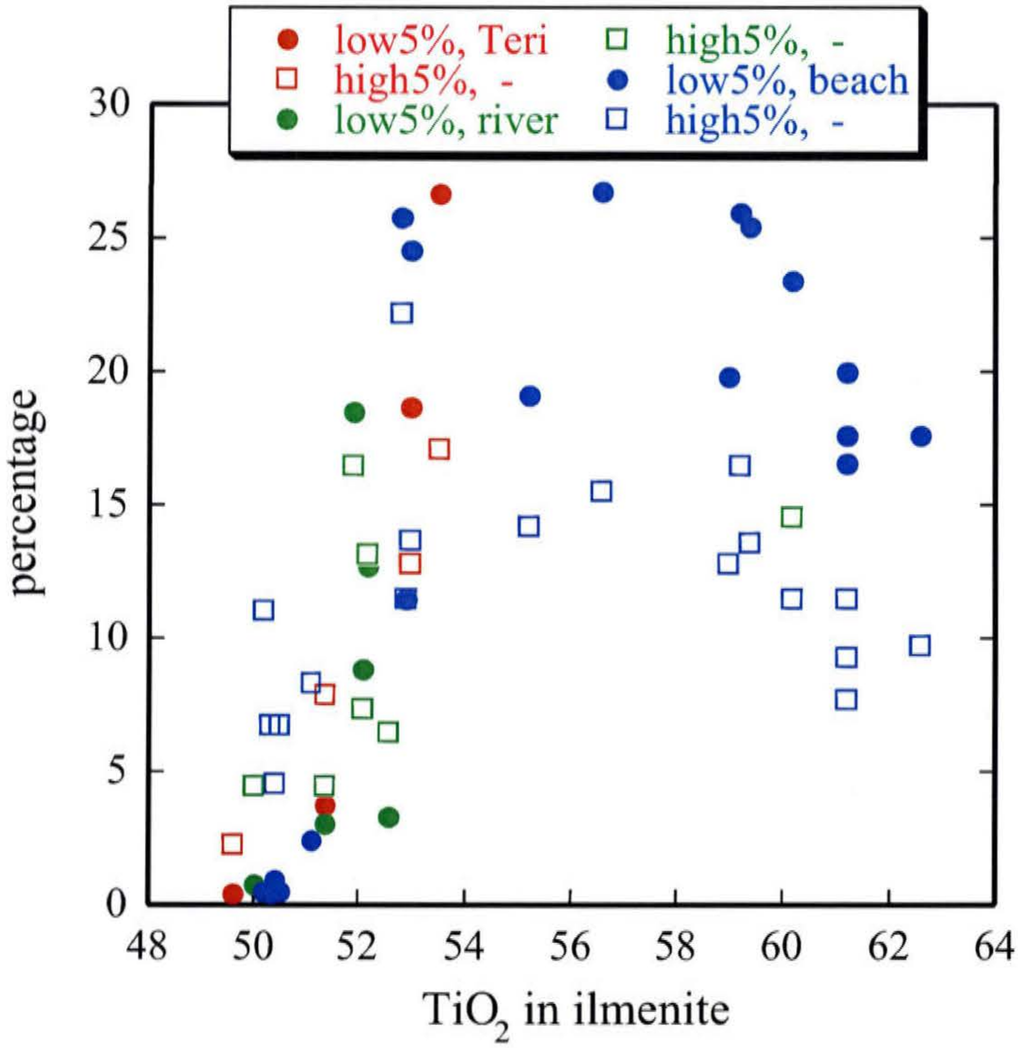


Figure 4

The result is demonstrated in Fig. 4, which shows that for samples with less than about 52 wt.% TiO_2 in average ilmenite, there are very few grains present with compositions outside that of the average +/- 5wt.% TiO_2. The percentage of average TiO_2 -5 wt.% ('low5%') and +5 wt.% ('high5%') is less than 10% for both. In other words - for samples with less than about 52 wt.% TiO_2 in average ilmenite, the distribution of TiO_2 is relatively narrow, which can be appreciated also by looking at the histograms in Fig. 3. For samples with average ilmenite TiO_2 > 52 wt.%, however, the distribution of ilmenite compositions changes to a more broad compositional range. For example, for sample # 50 with an average TiO_2 of 55.2 wt.%, there are 15% of the ilmenite analyses that have TiO_2 >60.2 wt.% (55.2+5%) and 16% with TiO_2 < 50.2 wt.% (55.2-5%). For the sample #12 with an average TiO_2 of 50.4 wt % the corresponding values are 1% and 5%, respectively. The larger variation in ilmenite composition with high TiO_2 in ilmenite also holds for samples with the most TiO_2-rich average ilmenite. Sample #29, for example, has an average TiO_2 in ilmenite of 61.2 wt.% and here the numbers of analyses with TiO_2 - and + 5 wt.% are 21% and 11%, respectively. For samples with average TiO_2 at about 50wt.%, the percentage of analyses with less than average TiO_2-5% is only a few percents, which reflects that these samples mostly have ilmenite which have retained their original metamorphic or igneous compositions. Fig. 4 also shows that samples with average TiO_2 higher than about 59 wt.% have a tendency of narrowing the distribution of ilmenite compositions, so that the maximum range is found for samples with average TiO_2 between 53 and 59 wt.%. This cannot only reflect a near-complete dissolution of Fe from the ilmenite at average TiO_2 >59 wt.%, because the decrease holds for both the populations of TiO_2 plus and minus 5%. It does, however, suggest that most grains in samples with average ilmenite TiO_2 >59 wt.% have been through prolonged leaching process or through a cycle of leaching processes that have affected the majority of grains.

Turning to the histograms of ilmenite composition in individual samples, (Fig. 3) it is also apparent that samples with average TiO_2 less than 52.6 wt.%, with a few minor exceptions, have no TiO_2-rich ilmenite grains present, while samples with average TiO_2 higher than about 60 wt.% do not contain grains with unaltered ilmenite compositions (49-51 wt.%.). The fact that the majority of the samples with average TiO_2 in ilmenite lower than about 52 wt.% indeed have very few grains with TiO_2 higher than the stochiometric value of 52.6 wt. % supports the suggestion above that in these samples, ilmenite grains have retained their original metamorphic or igneous compositions. The interpretation is that these samples contain ilmenite none of which underwent the required processes to alter it to high Ti-ilmenite or leucoxene. Alternatively, the contained ilmenite is of a composition that renders it resistant to the alteration processes. For the high average TiO_2 samples, the lack of unaltered ilmenite suggests that the leaching process is of local origin, so that no ilmenite grains that enter the sedimentary process in the given region escapes leaching. Alternatively, the (close) source of sediments is the site of extensive leaching of ilmenite, with subsequent focussed transport system to present deposits.

Modal composition of heavy mineral fraction.

The CC-SEM analysis returns information on the modal composition of the analysed heavy mineral fraction of the sediment sample (in terms of volume %). From Fig. 5a it is seen that the proportion of ilmenite in the heavy mineral fraction shows a weak and positive correlation with TiO_2 contents in average ilmenite. If one disregards the Teri Sand and river samples, the correlation becomes much more distinct so that samples with more than 50% modal ilmenite in the heavy mineral fraction all have elevated Ti contents in ilmenite. Also, for beach samples with less than about 40% modal ilmenite, the average ilmenite composition is the stochiometric 52.6 wt.% or less. In terms of modal content of leucoxene (Fig. 5b), there is, as expected, a good positive correlation for the samples with high average TiO_2 in ilmenite. Samples with low average TiO_2 in ilmenite invariably have low modal contents of leucoxene (less than 3%). However, there is a surprising variation in modal leucoxene abundance within the group of samples which are closely spaced along the Kerala coastline at Chavara. The samples show a small, but consistent, decrease in average ilmenite TiO_2 from sample #26 in the north with 62.6 wt.% TiO_2 over three samples (#27, #28 and #29) with identical values of 61.2 wt.% TiO_2 to sample #30 in the south with 59.0 wt. % TiO_2. This small decrease is accompanied by a large decrease in modal content of leucoxene, from 17.9 % in #26 to 2.7 % in #30 (Fig. 5b).

Modal content of silicates in the heavy mineral fraction, mainly pyriboles and excluding zircon and garnet, is low (less than about 10%) for the samples with elevated average TiO_2 in ilmenite, while samples with low average TiO_2 in ilmenite show large variation, from zero to more than 70% (Fig. 5c). If garnet is included in the silicate fraction, then most of the samples with low average TiO_2 in ilmenite show relatively high (> 40%) proportions of silicates (Fig. 5d). There are, however, still some samples with low proportions (<20%) of silicates, including three Teri Sand samples and a couple of beach sediments. The low silicate contents for samples with elevated TiO_2 in average ilmenite suggest that they are the result of deep alteration and leaching of sediments, although the low silicate contents in some Teri Sand and beach samples with low TiO_2 in ilmenite also suggest that this alteration does not necessarily affect the ilmenite content in the sediment.

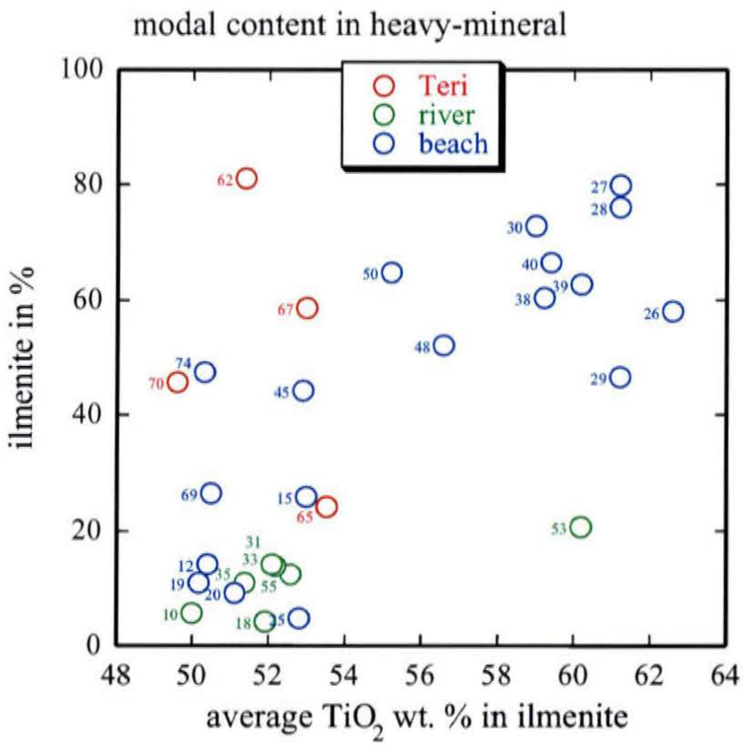


Figure 5a

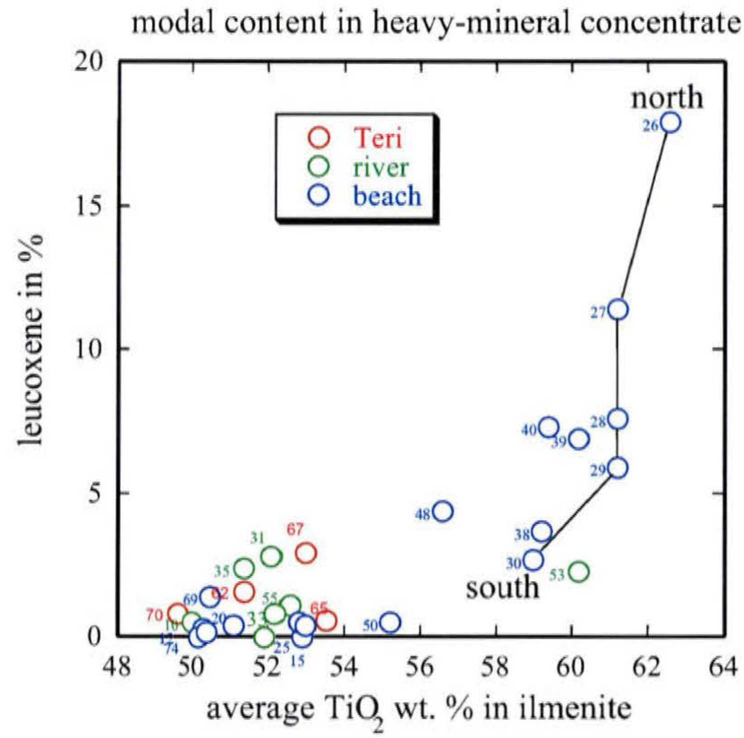


Figure 5b

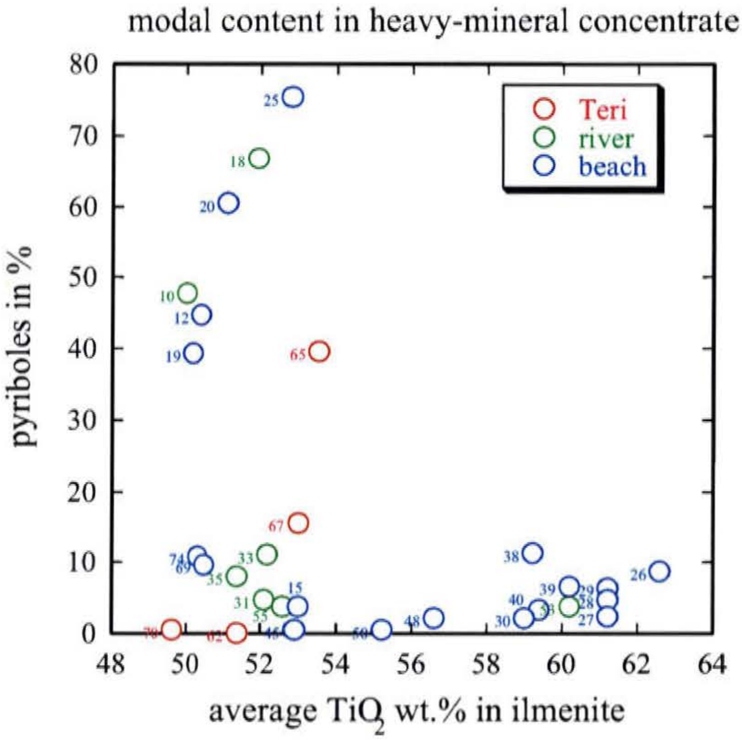


Figure 5c

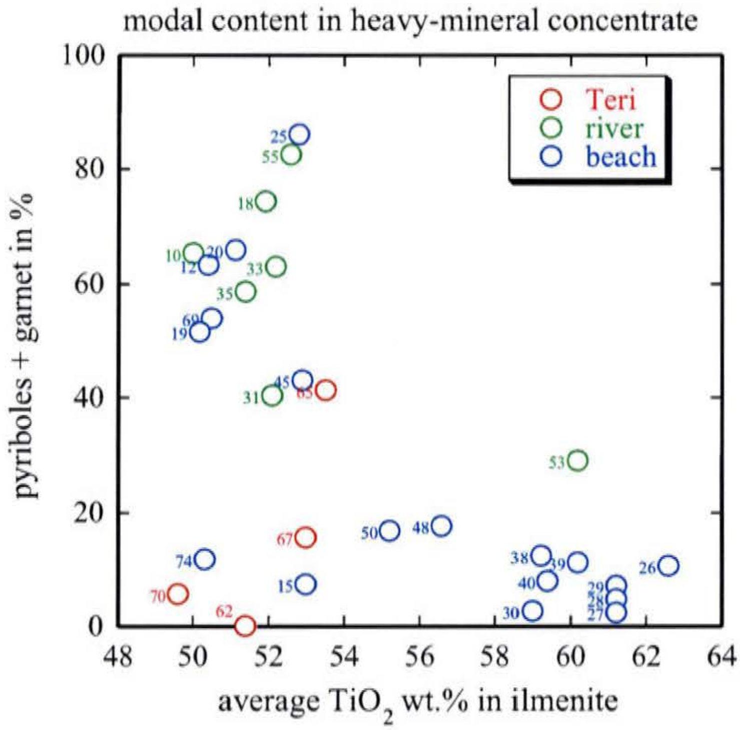


Figure 5d

Average CC-SEM data, chemistry and grains shape/size distribution.

Some of the suggestions stated above, based on the distribution of ilmenite analyses, can be further tested by the CC-SEM data on chemistry and grain shape/size for individual samples. In the following, all data has been reduced to average values for each sample to facilitate handling and analysis of data. Two mineral groups are found in abundances that allow a treatment with some statistical confidence, namely ilmenite and garnet. Note that in some of the following diagrams, the group of samples from the small Chavara district also appear (as blue filled circles), but they will be dealt with below in section *Local variation within the Quilon-Chavara region*, and the discussion here only concerns the samples represented by open circles.

Ilmenite.

From the diagrams of MgO and Al_2O_3 (Figs. 6a and 6b, respectively) it is apparent that the samples with elevated average TiO_2 (>55 wt.%) have more restricted range in chemical composition. For Al_2O_3 the high TiO_2 samples lie in the middle part of the compositional spectrum, while for MgO, high TiO_2 ilmenite are at the high compositional range. In terms of

SiO_2 (Fig. 6c), high TiO_2 samples are more widely distrubuted, with some samples at the extreme low end of the compositional range. For Nb_2O_5 and other elements such as MnO, there is no correlation with average TiO_2 in ilmenite (not shown).

Considering grain size and shape, expressed as grain length (Fig. 6d) and aspect ratio (Fig. 6e), respectively, samples with high average TiO_2 (>55 wt.%) appear to have a more restricted range in the given parameters, but within the overall range defined by all low TiO_2 samples. If excluding the three samples #50, #48 and #30, all samples with elevated TiO_2 fall within a grain length of 250 +/-20 micrometer, even if the one river samples with elevated TiO_2 #53 is included.

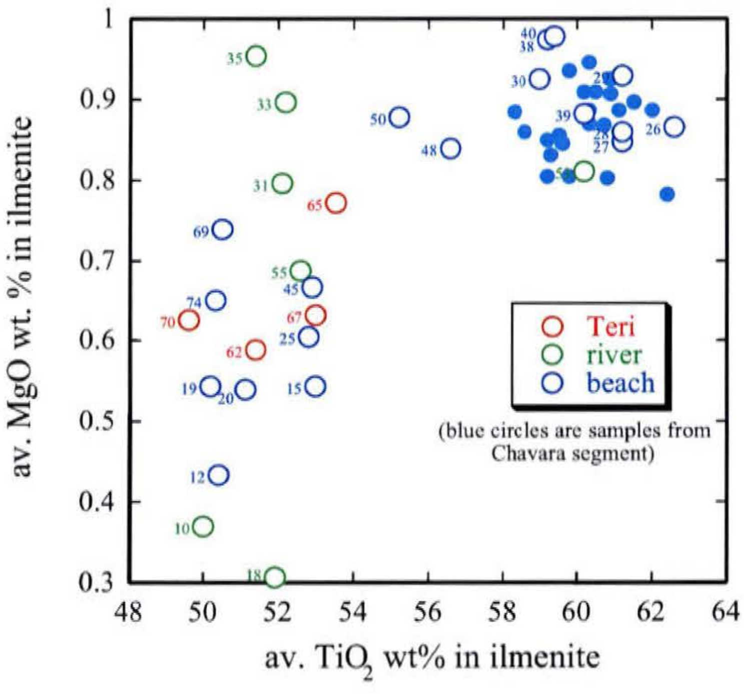


Figure 6a

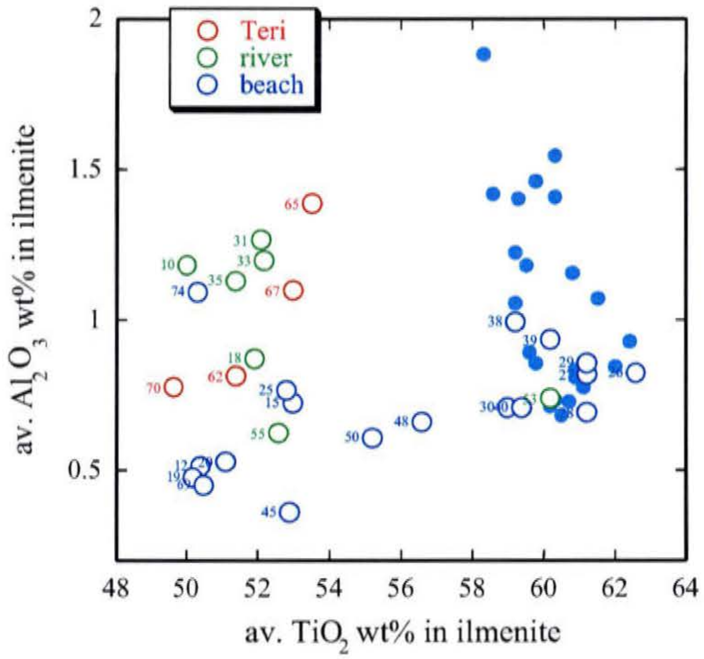


Figure 6b

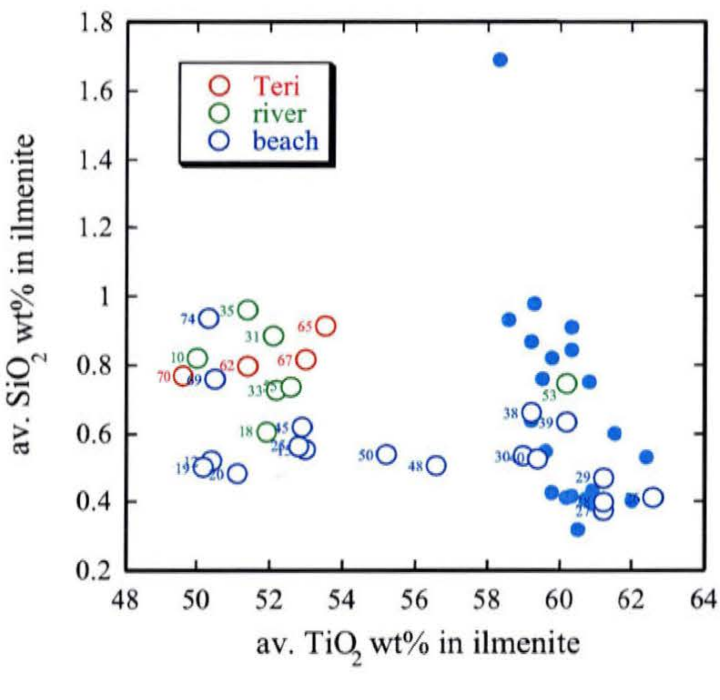


Figure 6c

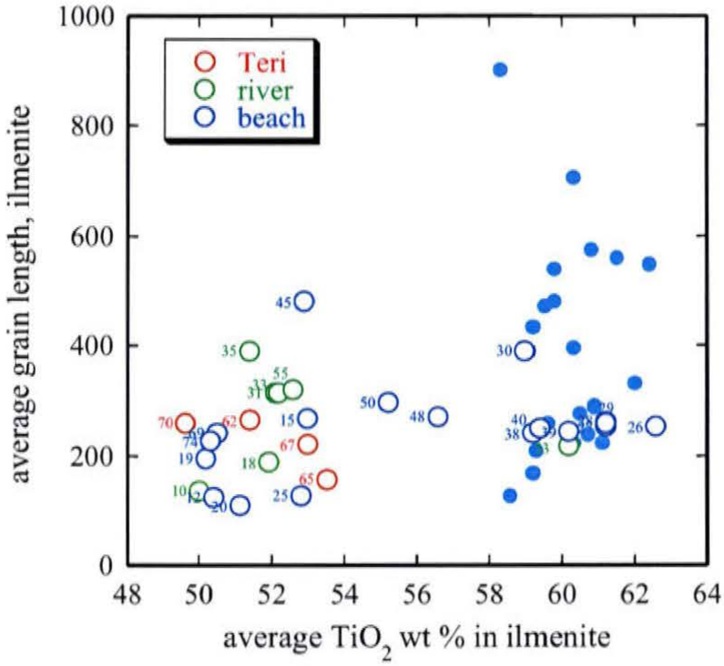


Figure 6d

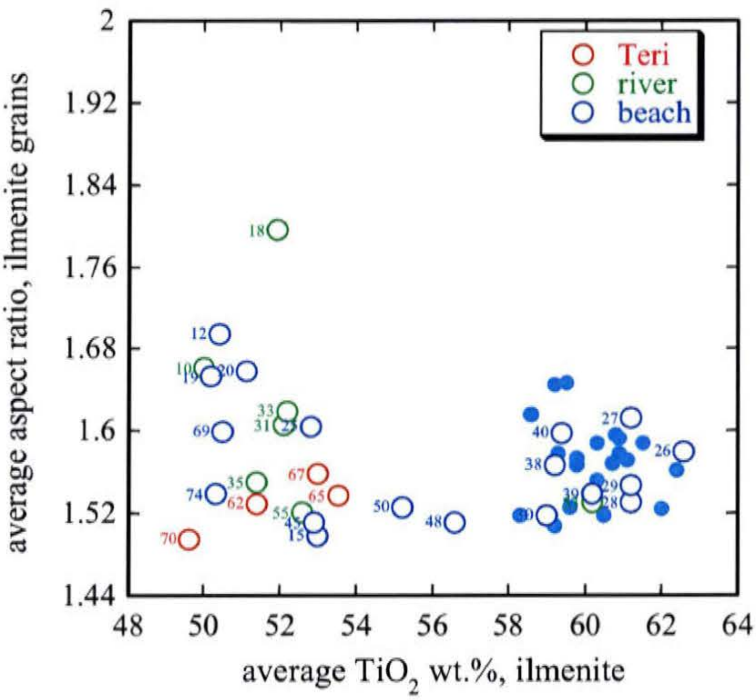


Figure 6e

Garnet

Variations in garnet compositions show similar restricted compositional ranges from samples with elevated average TiO_2 in ilmenite (>55wt.%). The most distinct variation is seen in the grossular component ($Ca_3(Al, Fe)_2Si_3O_{12}$), where the samples with elevated Ti in ilmenite invariable have low grossular garnets, whereas samples with low Ti ilmenites have garnets with both low and high grossular contents (Fig. 7a). For the Mg-Al garnet component, pyrope ($Mg_3Al_2Si_3O_{12}$), the samples with elevated Ti in ilmenite show a tendency to also having garnets with elevated contents of pyrope, allthough there are samples with high pyrope garnets also in the Teri Sand, beach and river samples from south and south east coasts (Fig. 7b). Average length and aspect ratio do not correlate with average TiO_2 in ilmenite. The compositional variation in terms of the three major garnet components pyrope (Py - $Mg_3Al_2Si_3O_{12}$), grossular (Gr - $Ca_3(Al, Fe)_2Si_3O_{12}$), and almandine-spessartine (AS - $(Fe,Mn)_3Al_2Si_3O_{12}$) are depicted in the triangular diagrams in Fig. 7c, arranged as in Fig. 3 in order of decreasing TiO_2 in average ilmenite. In addition to showing the above mentioned deficiency in grossular for the garnets from samples with elevated TiO_2 in ilmenite, the compositional triangular diagrams also show that for some samples with low TiO_2 in ilmenite, there is a considerably larger variation in garnet compositions.

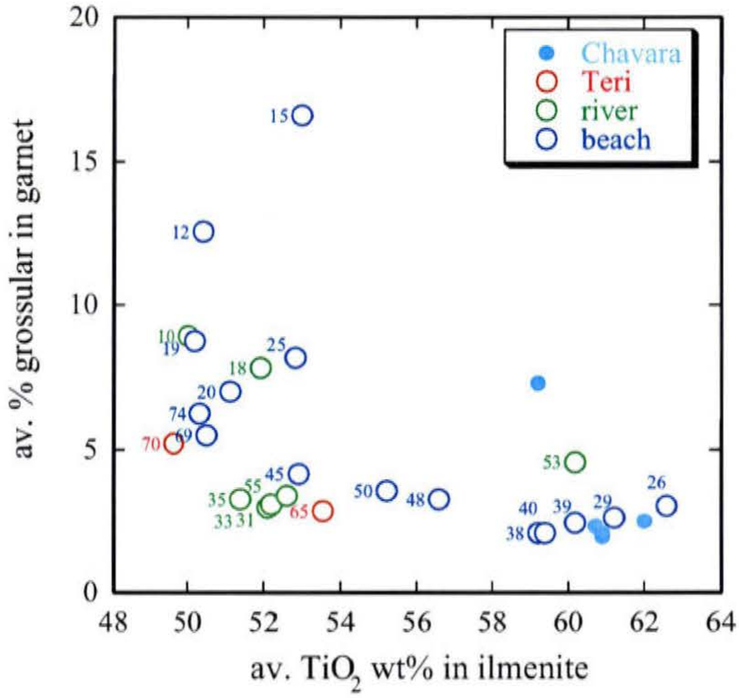


Figure 7a

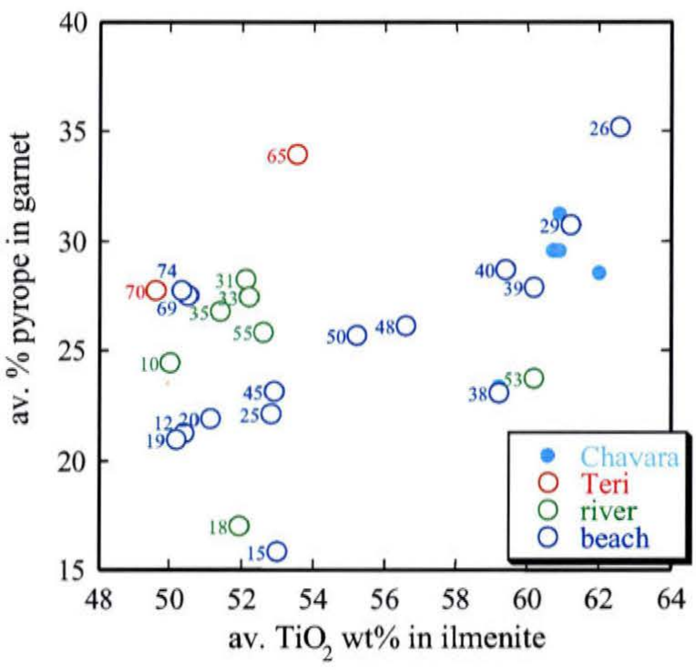


Figure 7b

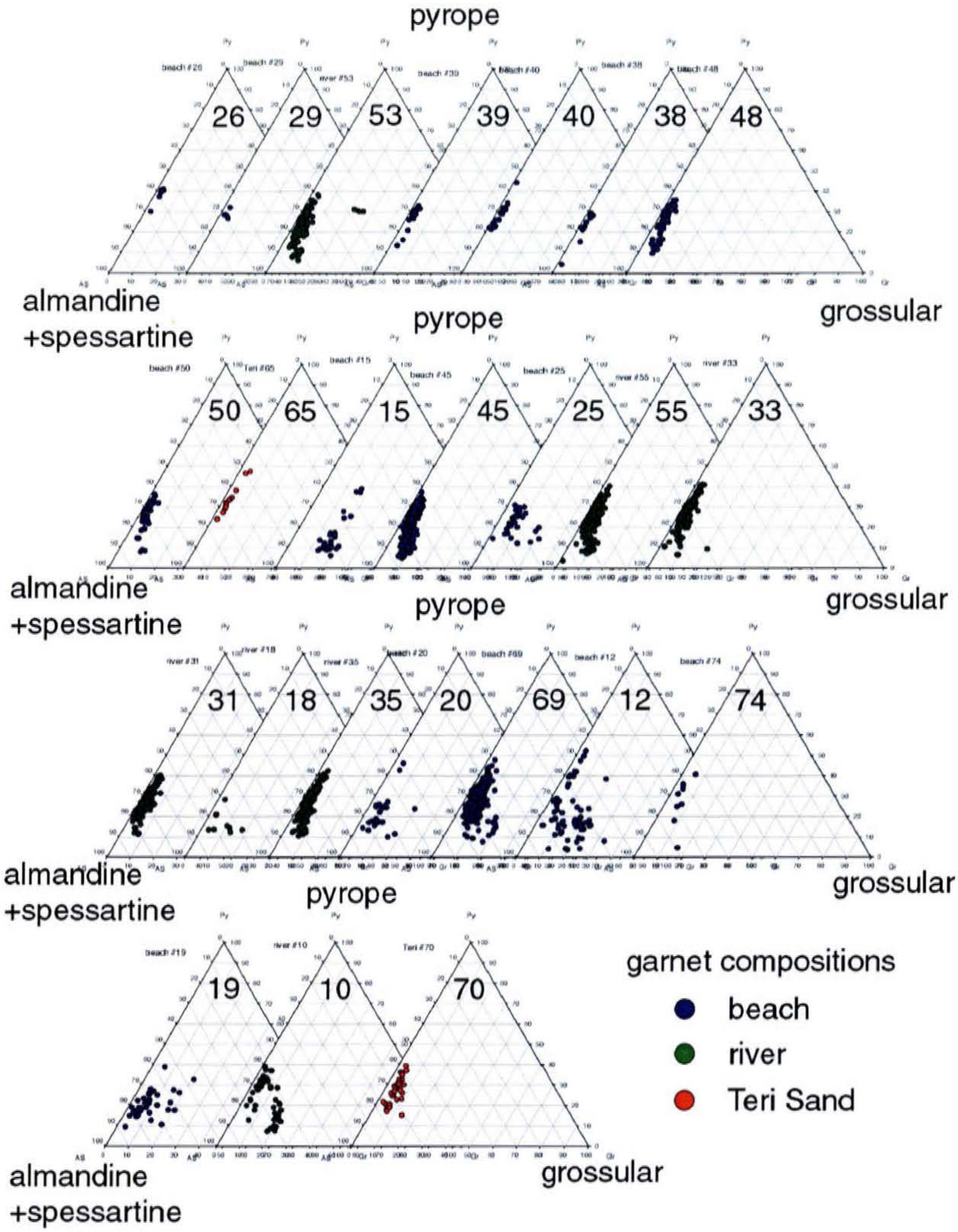

pyrope
26
29
53
39
40
38
48
almandine
+spessartine
grossular
50
65
15
45
25
55
33
31
18
35
20
69
12
74
19
10
70
garnet compositions
beach
river
Teri Sand

Figure 7c

Some considerations on the CCSEM data

The restricted chemical compositions of ilmenite for samples with elevated TiO_2 contents in average ilmenite, cannot only be related to the chemical changes during the leaching process, since the range in compositions for low TiO_2 samples is considerable larger and includes the range as defined by the high TiO_2 samples. This holds for SiO_2, MgO and Al_2O_3 (Figs. 6a-c). The high MgO contents in ilmenite from high TiO_2 samples (Fig. 6a) is conflicting with the statement by Force (1991) that MgO content falls with progressive degree of leaching. Post-leaching addition of clay minerals to the porous ilmenite grains cannot be responsible for the high average MgO since Al_2O_3 does not show a similar high level, and since SiO_2, although variable, is low in ilmenite for samples with elevated TiO_2 (Fig. 6c). The more restricted variation in Al_2O_3 and MgO for ilmenite with elevated TiO_2, suggests that the leaching process responsible for the increase in TiO_2 is more efficient for ilmenite of certain compositions. This interpretation is supported by the garnet compositional data, showing a similar restricted range in compositions for garnet from samples with elevated TiO_2 in ilmenite. For example, no samples with average grossular in garnet higher than about 5 % have elevated TiO_2 in ilmenite, which is remarkable, since the entire range for grossular in garnet is 2.0 to 16.7 % (Fig. 7a).

Bulk-rock geochemistry

The raw, unprocessed material of all 45 sediment samples were analysed by XRF with the results given in Table 2 (Appendix 3). The results given in Figs. 8a-d, show firstly that average TiO_2 in ilmenite, as analysed by CC-SEM and discussed above, correlates with several parameters. For instance, Fe_2O_3/TiO_2 shows a negative correlation with TiO_2 in ilmenite (Fig. 8a). All beach samples with elevated TiO_2 in ilmenite (i.e. TiO_2>55 wt.%) have Fe_2O_3/TiO_2 lower than 0.6, and excluding the one river sample #53 and the Teri Sand sample #62, there is a considerable compositional gap between the samples with elevated TiO_2 in ilmenite (Fe_2O_3/TiO_2<0.55) and the samples with low TiO_2 in ilmenite (Fe_2O_3/TiO_2>0.95). Two other element ratios are of interest here, namely Sr/Nd (Fig. 8b) and La/Nd (Fig. 8c). The samples show a huge variation in Sr/Nd over nearly five orders of magnitude. The samples with low average TiO_2 in ilmenite form a cluster with Sr/Nd of between 0.31 and 30.4, excluding the one Teri sample #62 with Sr/Nd as low as 0.0014. The samples with elevated TiO_2 in average ilmenite all have low to very low Sr/Nd values, and show a weak positive correlation with ilmenite composition. A similar relationship is displayed by the La/Nd ratio (Fig. 8c) where the samples with low TiO_2 in average ilmenite form a group with high values, again excluding the Teri sample #62 and one beach sample #15. Samples with high TiO_2 in average ilmenite have low or intermediate La/Nd.

The distinct correlation between ilmenite TiO_2 contents and bulk-rock chemistry also holds for K_2O (Fig. 8d), where all samples with elevated TiO_2 in ilmenite have low to very low K_2O contents, whereas most of the low Ti ilmenite samples have K_2O higher than 0.5 wt.%. The exceptions only count four samples, among them again the Teri sample #62 and beach #15.

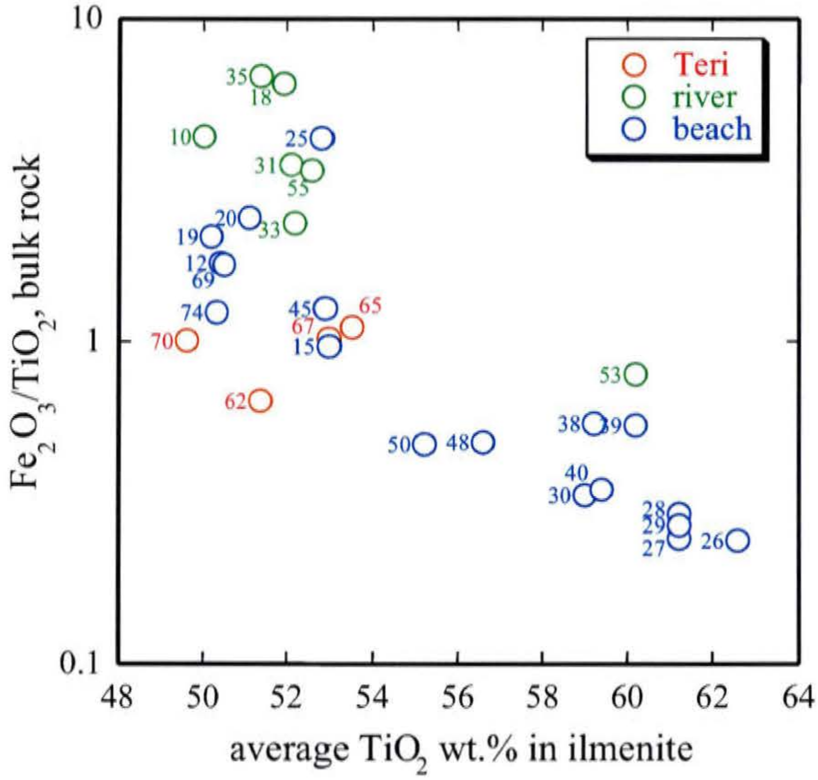


Figure 8a

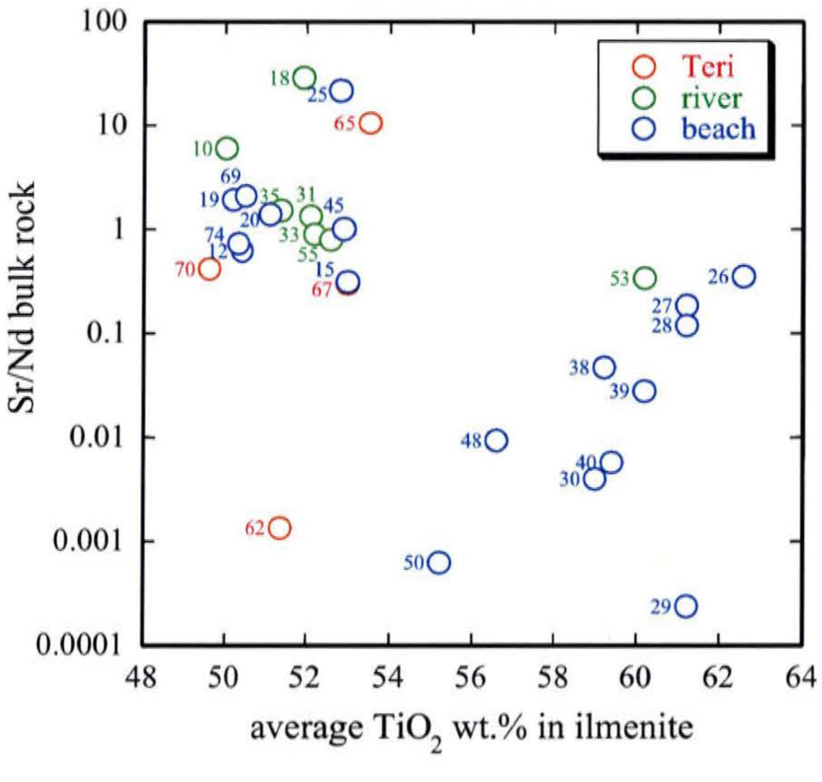


Figure 8b

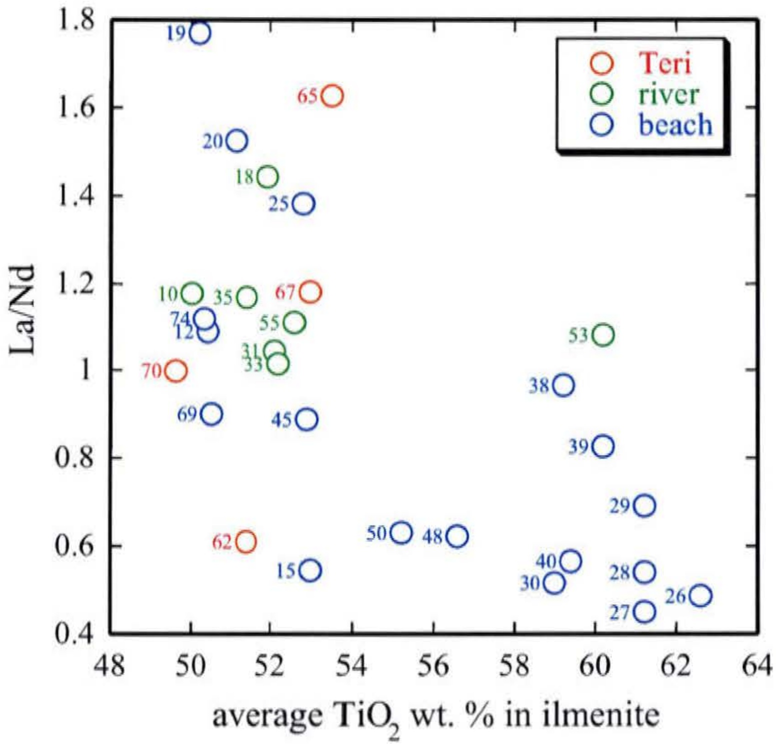


Figure 8c

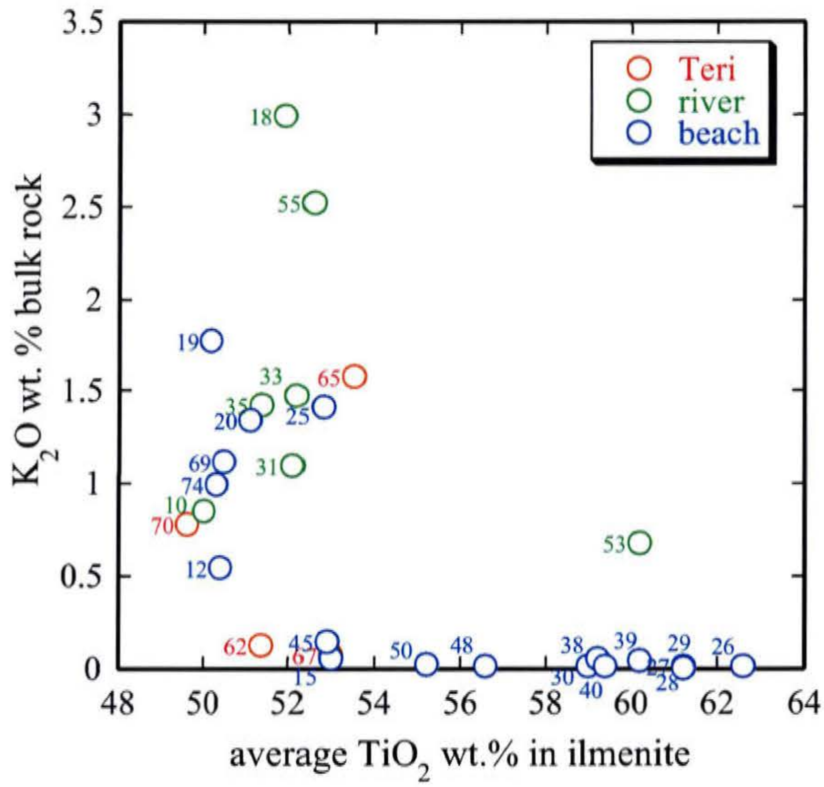


Figure 8d

Interpretation of bulk-rock geochemistry

It is evident from Fig. 8e, that Fe_2O_3/TiO_2 strongly reflects the proportion of ilmenite in the samples. High Fe_2O_3/TiO_2 invariably reflects a low ilmenite content, i.e. less than 5%, and since there is a correlation between TiO_2 in ilmenite and modal content of ilmenite (Fig. 8f), it must be these relationships, which are responsible for the correlation between Fe_2O_3/TiO_2 and average TiO_2 in ilmenite (Fig. 8a). The varying Sr/Nd is partly caused by variation in modal contents of monazite (Fig. 8g), which is the main host of light rare earth elements (LREEs) and thus establishing a negative correlation between Sr/Nd and modal monazite. The La/Nd ratios, illustrated in Fig. 8c, do not correlate very well with any single mineral as analysed by the CCSEM, but there is a good overall correlation with total content of heavy minerals in the sample, which is shown in Fig. 8h. This suggests that the La/Nd ration too is controlled by the composition of the heavy mineral fraction in the sediment sample.

Since it is shown above that the bulk chemistry mainly depends on the proportion of heavy minerals in sample, the interest now focuses on the three samples #38, #39, and #53 , which all have low to intermediate proportions of heavies, as illustrated in Fig. 8h. These represent beach sediments (#38 and #39) and the one river sediment (#53) with elevated TiO_2 in average ilmenite. The main point to be extracted from the chemistry of these three samples, is, that in spite of their relatively low proportions of heavy minerals (21.7%, 39.2% and 40.0%, by weight, respectively, and see Fig. 8h) compared to all other samples with elevated TiO_2 in average ilmenite, which have more than 85 weight % heavy minerals, these three samples have low Sr/Nd. This low Sr/Nd in the three samples is unlikely to be caused by their modal contents of monazite (Fig. 8g), as this is low too. Also, for the two beach samples #38 and #39, their low concentrations of K_2O that places them along with the other samples with elevated TiO_2 in ilmenite (Fig. 8d), cannot be explained by high proportions of heavy minerals in the samples. It is therefore suggested that the low K_2O and low Sr/Nd of the samples with elevated Ti in ilmenites is partly a reflectance of the leaching process that the ilmenite-bearing sediments at some time were subjected to, or could be a signature of the source of leachable ilmenite.

There is some evidence that the low K_2O and Sr/Nd can be explained in terms of removal of a feldspar component from the sediments. The river samples #31, #33, #35, #55 and also to some extend the Nambiar river sample #53 all have higher K_2O and Sr/Nd than all beach sediments with high TiO_2 ilmenite, consistent with the existence of feldspar in these unmature sediments, whereas all beach sediments from this southern part of the study area are low in these two parameters (Fig. 8b, except #45; and Fig. 8d). However, beach samples from the coast north of Alleppey, e. g. #20, #19, and #12 in addition to several beach samples along the Tamil Nadu also have relatively high Sr/Nd and K_2O, which suggests that it is not only the presence of feldspar which controls the values of these chemical parameters.

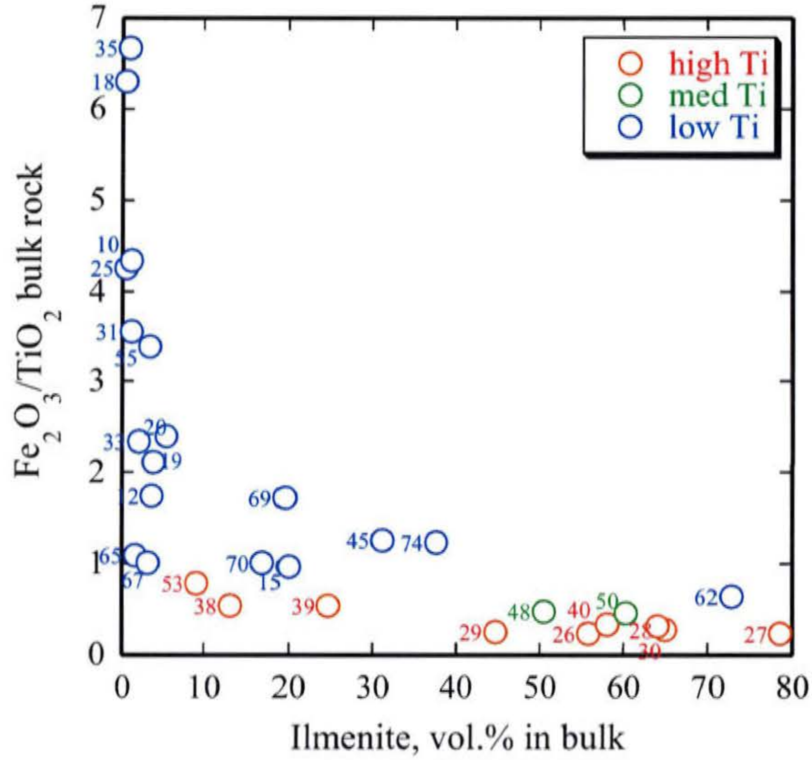


Figure 8e

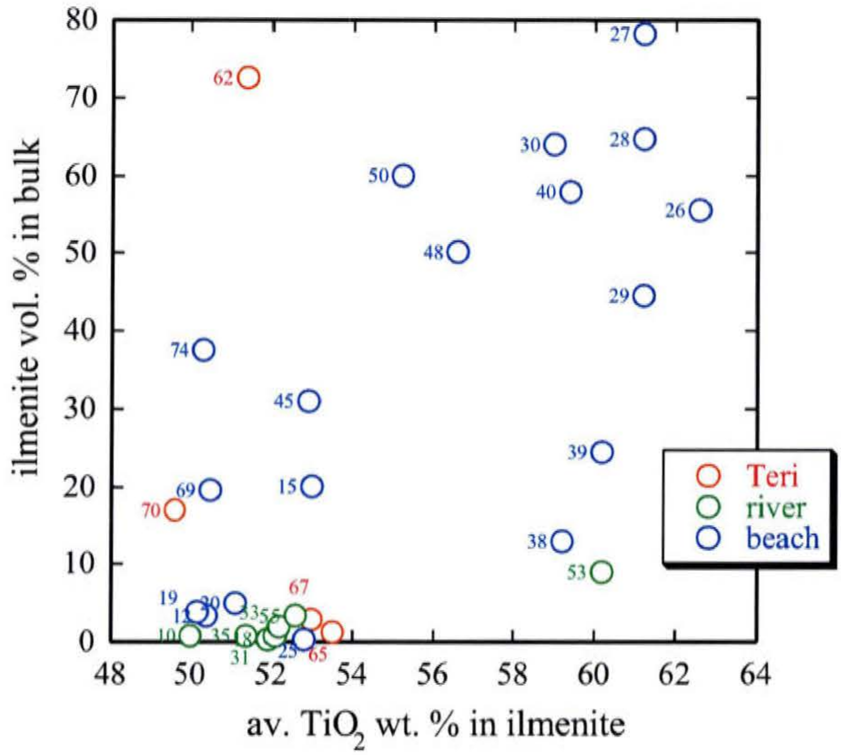
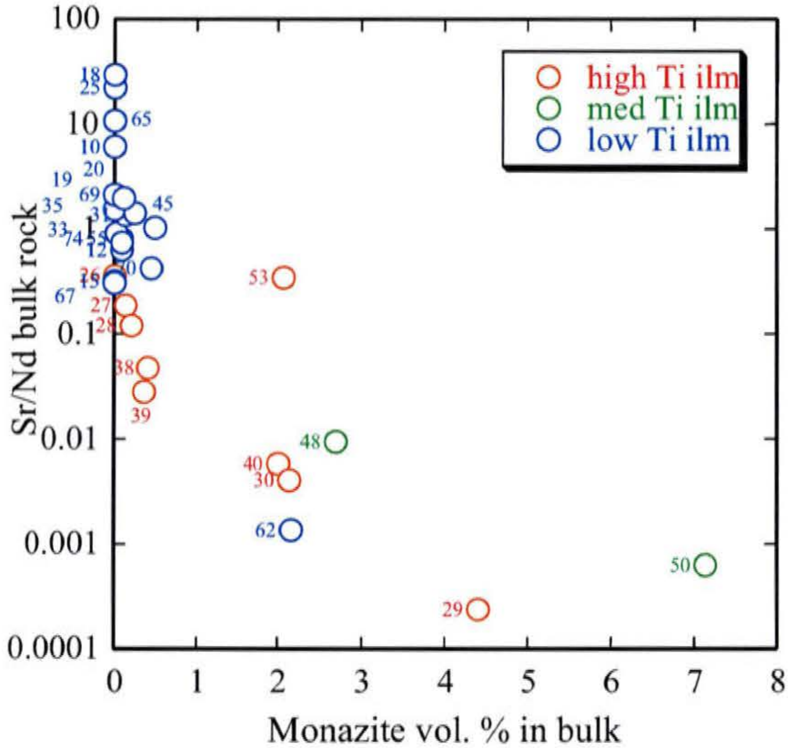


Figure 8f



Figur 8g

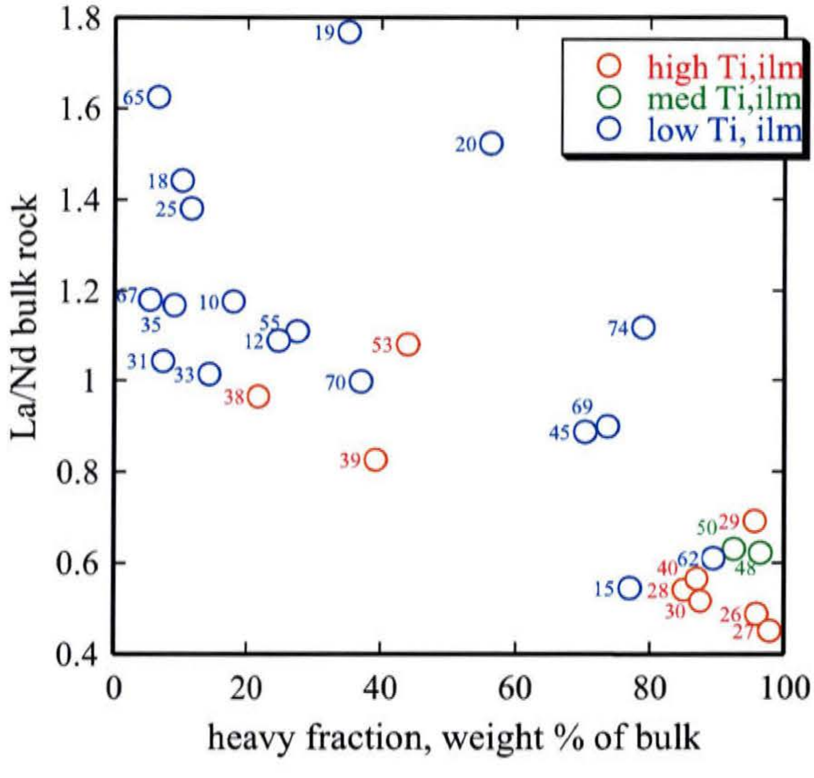


Figure 8h

Correlation with geology.

The general geological framework of Kerala and south Tamil Nadu is presented in Fig. 1. Most of the basement rocks consists of Archaean gneisses, mainly hornblende-biotite gneisses and charnockites. Across the southern tip of the states, a belt of Archaean supra-crustal rocks dominate, with lithologies of garnet-biotite gneisses and garnet-silimanite-graphite schists. Precambrian granite plutons are found mainly in the northwest, but only in the northern part of Kerala State, these plutons occur close to the coast line. Most of the coast line and several kilometers onshore, are occupied by Cenozoic sediments, being fluvial, fluvio-marine , marine and aeolian clastic sediments. In addition, some larger areas of extensive laterite formation are found in relatively short distance from the coast (5-20 km). The samples collected for this study are all of recent beach deposits, aeolian reworked marine sands (Teri Sands) and recent river sediments, all represented by circles in the colours blue (beach), red (Teri Sand) and green (river), in Fig. 1. The main result of the 2002 sampling programme was the identification of samples with elevated TiO_2 in average ilmenite from a sequence of beach deposits in southwestern Kerala State, between the towns of Alleppey and Trivandrum and apparently continuing south towards the southern tip of India, but with some indication of a decreasing Ti grade of the ilmenite going south from Trivandrum. It is within these stretches of coast that the Chavara and Manavalakurichi deposits occur.

One first order observation in the present data set is the apparent correlation of the samples with elevated TiO_2 in ilmenite and the basement geology. The coastal stretch from Alleppey south towards the southern tip of India is also in close proximity with the occurrence of the khondalite suite rocks. The two samples with intermediate TiO_2 in ilmenite (#50 and #48) are found at the border between the khondalite suite to the north and a block of charnockite rocks in the extreme south (Fig. 1). The one occurrence of elevated TiO_2 in ilmenite at the East Coast of south India (river sample #53) is located where the khondalite belt meets the coast. There is also supporting evidence for this correlation from the ilmenite and garnet chemistry. In addition to the beach sediment samples, there is a series of inland samples taken from rivers within the khondalite suite. When turning to Fig. 6a, it is apparent that the high MgO found in ilmenite with elevated TiO_2 is also found in ilmenite from the three river samples #31, #33, and #35, while #55 is somewhat lower. In terms of garnet compositions, the restricted, and low, average contents of grossular and elevated contents of pyrope (Figs. 7a and 7b, respectively), found in samples with elevated TiO_2 in ilmenite, are closely resembled by the garnets found in the samples #31, #33, #35, and #55. The low grossular component in average garnet from these samples are representative for garnets from metasediments in granulite facies, and has indeed been described as typical for garnets in detrital sediments from the coast of the southern tip of India by Sabeen et al. (2002). These authors also link the presence of high pyrope - low grossular garnets in the beach and dune sediments to a source in the khondalite belt of south India, rather than to the charnockites.

The results presented in this report is demonstrated in terms of the lateral variation in garnet compositions in Fig. 9. It is clear that the samples with a diverse group or groups of garnets come from the river and beach samples of the northern Kerala coast (samples #10-

#25, north to south). From south of the town of Alleppey the garnet populations show much more restricted range in compositions both with respect to samples of beach and river sediments. When moving up the east coast of Tamil Nadu the garnets again become more compositionally diverse, but maintain a strong component of the low grossular-high pyrope compositions. Thus, the data obtained for this study confirms, and even strengthens the findings of Sabeen et al. (2002) because of the strong link genetic link between beach sands and river sediments from within the khondalite belt indicated by the garnet compositional data. In addition our data demonstrates the correlation of sediment with hinterland geology, such as the charnockites, hornblende-biotite gneisses and granites of the northern part of Kerala State (Fig. 9).

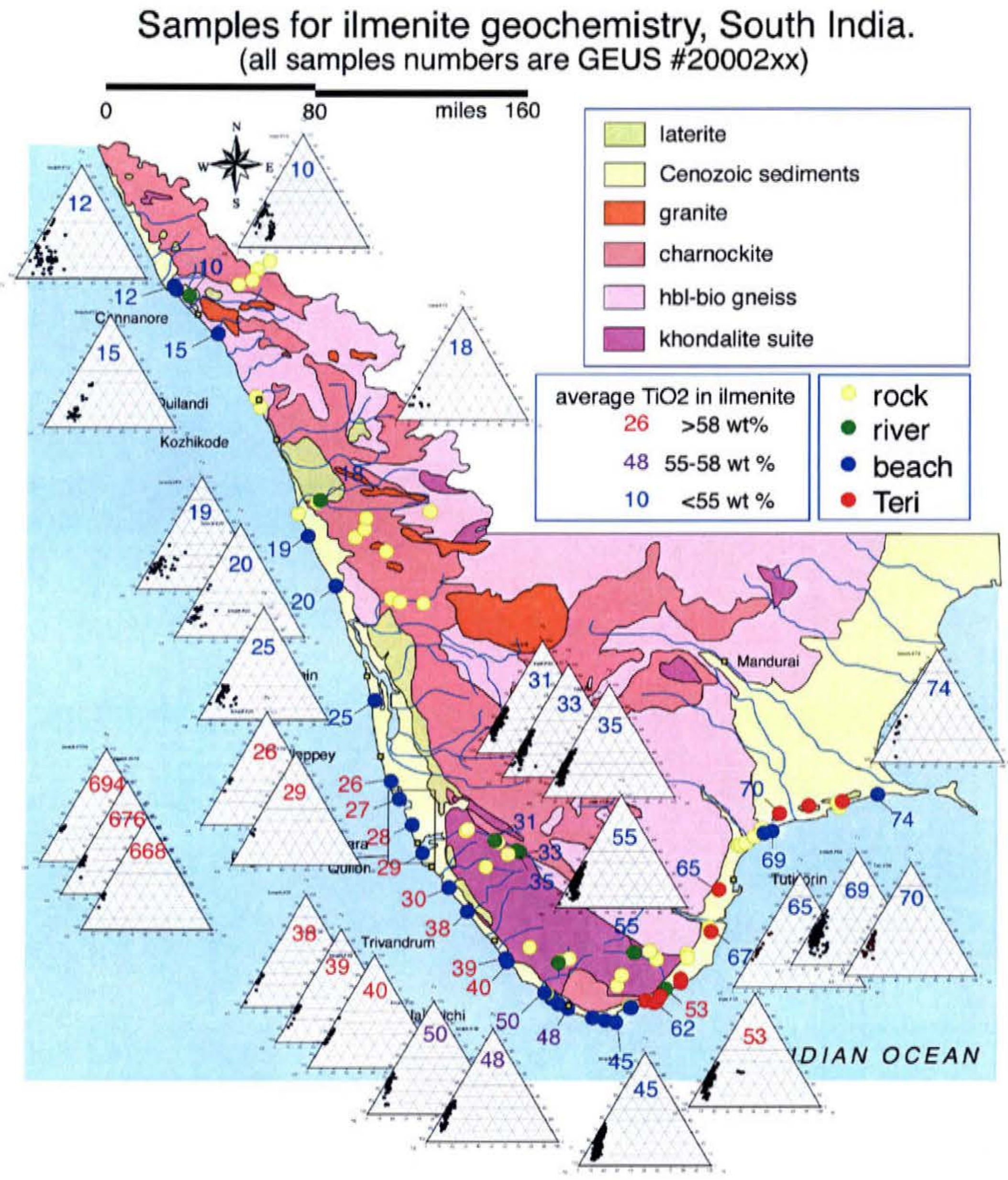


Figure 9

Indeed, based on the heavy-mineral assemblage of the Chavara deposits, Soman (1985) suggested that these heavy mineral deposit originated from the khondalite complex of south Kerala, emphasizing the presence of sillimanite as the key consituent of both lithologies. Soman (1985) also briefly described the prograde reaction of Ti-biotite + Al-rich solutions to sillimanite + ilmenite + K^+ which not only links the formation of sillimanite to that of ilmenite, but also explains how ilmenite is formed by a process which differs fundamentally in P and T from the ilmenite forming process in igneous rocks.

As stated in the introduction, ilmenite is a widespread ascessory mineral in nearly all basement lithologies of southern India, and ilmenite also forms an important constituent of the heavy-mineral fraction in beach and river sands. The main question regarding the occurrence of the high Ti ilmenite in beach sands of south India must therefore be whether all ilmenite from the different source lithologies possesses the same potential of being leached, so that variations in post-weathering and -erosion processes determine whether ilmenite in beach sediments eventually reaches the state of high Ti ilmenite, or, more correctly, pseudorutile. The drainage systems, transport mechanisms and climate appear to be very similar along the beach of Kerala state, while the more arid Tamil Nadu coast differs in having less precipitation, lower energy coast lines and longer drainage systems. The Kerala coast line therefore is potentially the most useful in constraining the Ti-enhancement processes in ilmenite. Given the similarities of the present day physical and chemical environment along the Kerala coast as mentioned above, the main parameter to variate along the coast would appear to be that of basement lithology. This view is substantiated by the study of Mallik et al. (1987) who describe the variation of heavy mineral assemblage in beach and river sediments along the entire Kerala coast. Their study, which is based on 60 samples in total, with 28 being from beaches and 32 from rivers, shows that the sediments can be divided into five provinces, which, from north to south are: 1) mixed province with opaques, zircon, hornblende, garnet, sillimanite, epidote; 2) garnet-hypersthene; 3) opaques-zircon; 4) hornblende-hypersthene, and 5) opaques-zirkon-monazite with sillimanite-epidote. In terms of provenance for the sediments, the authors link these provinces to the variation in lithologies in the basement rocks, so that provinces 1) and 4) with abundant hornblende is associated with retrograded granulite facies gneisses in the north and south; province 2) with abundant hypersthene is linked to the charnockites of the central Kerala state and, of particular interest here, province 5) with common sillimanite linked to the khondalite belt. In Fig. 10, these relations are illustrated in addition to the data from the present study. Samples of Mallik et al. (1987) with high proportions of hypersthene ('H' in Fig. 10) show dense clustering in the middel part of the Kerala coast line and in rivers of that area. This corresponds to the dominance of charnockites in the basement rocks. The Mallik et al. (1987) samples showing relatively high proportions of sillimanite ('S' in Fig. 10) are mostly found in the northern sector, around the town of Cannanore; a few in the middle, some 50 miles south of Kozhikode; and along the entire coastline from Alleppey to Trivandrum. These results are in accordance with the study of Prakash (2000) on the composition of inner shelf sediments off the coast of Quilon, where it was found that sillimanite is the second most abundant heavy mineral present, after the group of opaques. The samples collected and processed for this study are also presented in Fig. 10, and they are largely in agreement with the Mallik et al. data. Our data further supplement the Mallik et al. (1987) data around the southern tip of India. As evident from Fig. 10, there is a strong correlation between the occurrence of sillimanite in the beach and river sediments and the occurrence of khondalite suite rocks in the inland basement. The few occurrences of samples with high sillimanite contents, north of Alleppey could be associated with smaller enclaves of khondalite lithologies upstream from the rivers. It is possible that the occurrence of sillimanite in Teri Sand and beach samples from the east coast of southern India similarly have their origin in isolated enclaves of khondalite, for instance around the town of Mandurai.

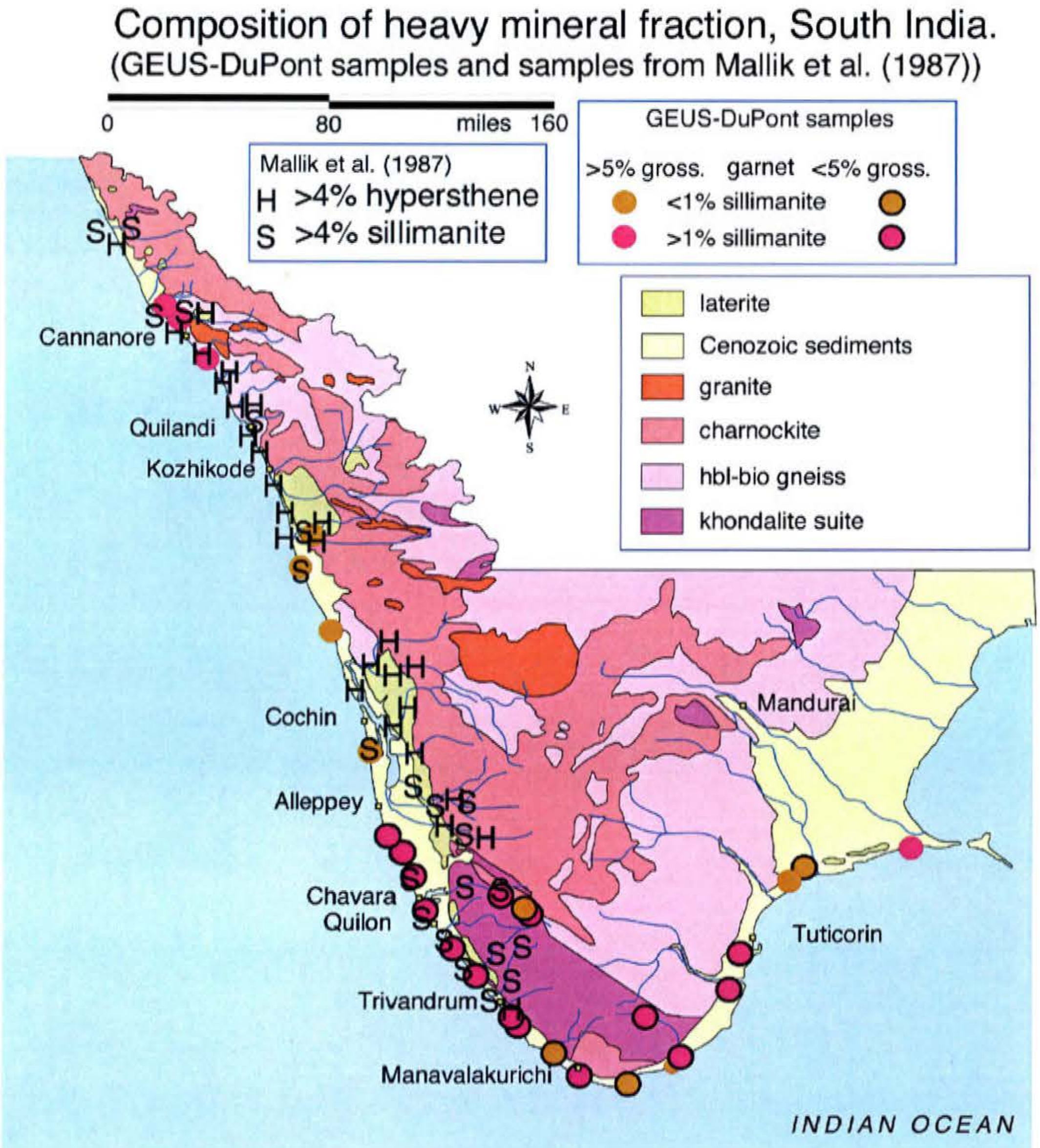


Figure 10

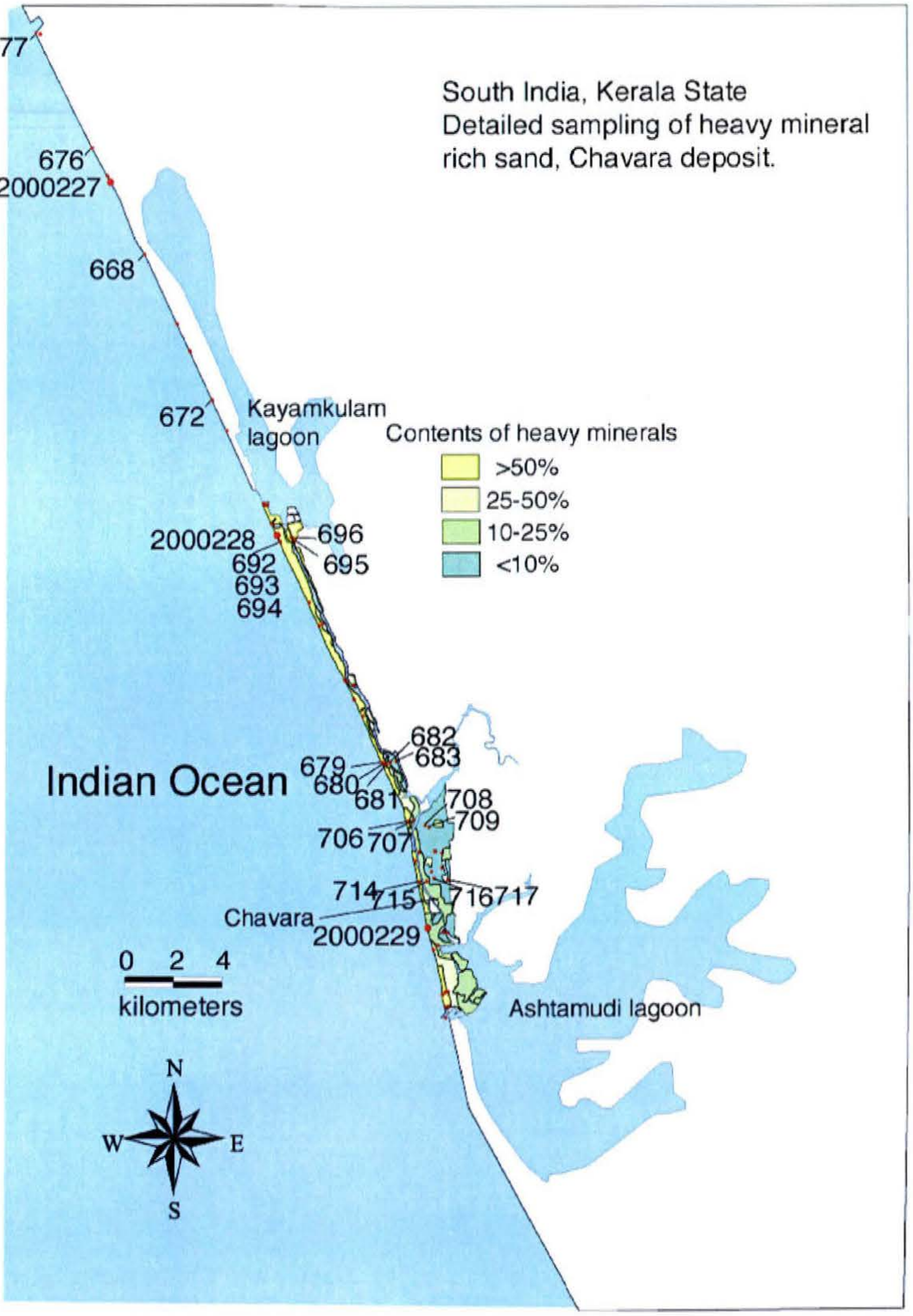
From the considerations above we conclude that the heavy mineral composition of beach sediments of Kerala coast strongly reflects the lithologies of basement rocks upstream from the river drainages. Coupled with the evidence from ilmenite and garnet mineral chemistry presented above we find strong arguements for a model in which ilmenite from granulite facies metasediments (khondalites) are prone to the leaching processes which acted on the sediments after their removal from the weathered source rocks. The leaching processes must further have occurred in the coastal areas, since all of our river samples have low TiO_2 in average ilmenite. The one exception to this statement is river sample #53 from the Nambiar river, east of the southern tip of India. This sample was, however, taken close to the mouth of the river, where the detrital material is likely to include a component of re-worked palaeo-beach sediments.

The main source for the modern beach deposits in Kerala are fluvial sediments, supplied by river systems during the Neogene, and reworked in shallow tidal marine facies (Nair et al., 2002). In the Miocene, uplift of the basement resulted in a west-facing gradient of the central basement gneisses and accumulation of thick sequences of fluvial sediments in the Eastern Arabian Sea. Further uplift in the later Pliocene also subjected Tertiary formations to erosion. In the Quaternary, there was a series of fluctuations of the shoreline, with subsequent transgression in the late Pleistocene (Nair et al., 2002). The beach sediments thus show a long history of deposition and reworking in shore-proximate areas. This is in accordance with the work of Mallik (1986) describing the morphology of heavy minerals in beach samples from the Chavara and Manavalakurichi coast line, and showing that the ilmenite grains carried evidence of several stage of intense mechanical and chemical erosion.

There appears to be a net transport of sediment to the NW along the south and central Kerala coast (Kurian et al., 1996). The increasing grade of ilmenite and increasing proportion of leucoxene in the sediments along the coast from sample #30 in the south, over sample #28 at Chavara to #26 in the north (Fig. 5b), may thus be explained in terms of progressive leaching and sorting of the sediment material towards the north. This also coincides with the increasing area of Cenozoic sedimentary cover along this coast segment (Fig. 1). Such a history of prolonged exposure to mechanical and chemical weathering in coastal environment is also compatible with the observation (see above section *Distribution of ilmenite compositions in terms of TiO_2 in individual samples*, and Fig. 3), that samples with high TiO_2 in average ilmenite contain no or very few grains of unleached ilmenite, with a suggestion of a pervasive leaching process with a local (in the sense of 50-100km) source of material.

Local variation within the Quilon-Chavara region

In the pre-monsoon period, 61 samples were collected from Quilon in the south (Fig. 11; near sample #29 from the 2002 sample collection), over Chavara (2002 sample #28) to Thottapalli in the north (ca. 6km north of 2002 sample #27). Of the 61 samples, some 22 were run by CCSEM in the fall of 2003, and these samples are depicted in Fig. 11 with 3 sample number digits (Table 3, appendix 3). Details on the sampling programme can be found in report by Srinivasan and Vasudev (appendix 1).



South India, Kerala State
Detailed sampling of heavy mineral rich sand, Chavara deposit.
677
676
2000227
668
672
Kayamkulam lagoon
Contents of heavy minerals
>50%
25-50%
10-25%
<10%
2000228
692
693
694
696
695
682
683
679
680
681
708
709
706
707
714
715
716
717
Chavara
2000229
Indian Ocean
0 2 4
kilometers
Ashtamudi lagoon
N
W
E
S

Figure 11

The samples were collected in order to test the local variation within the Chavara deposit both in terms of along-beach variation and across-beach variation. The samples were therefor taken in several traverses perpendicular to the coast line, each consisting of four or five samples, taken from the shore line, in dunes and at the inland systems of lagoons, islands and canals, respectively (Fig. 11). The 22 samples selected for CCSEM include: One traverse about 2km north of sample #29 (samples #714-#717), one traverse 5km north of #29 (samples #706-#709), one traverse 7km north of #29 (#679-#683), and one traverse immediately south of sample #28 (samples #692-696). In addition, two samples between #28 and #27 (#668 and #672) and two samples north of #27 (#676 and #677) were included. As also shown in the map of Fig. 11 and in Table 3, there is much local variation in the heavy mineral proportion of the sediments, which has been mapped into areas based on classes with >50% to <10% heavy minerals.

It is evident from Fig. 6a, that all samples from the Quilon-Chavara segment of the Kerala coast (hereafter referred to as 'Chavara segment') have elevated TiO_2 and MgO in ilmenite, and fall roughly within the field defined by all high TiO_2 ilmenite samples from the 2002 sample collection. For Al_2O3 and SiO_2 (Figs. 6b and 6c) the Chavara segment samples expand the compositional fields of the 2002 samples considerably, mainly for the high TiO_2 ilmenite samples, but also for the overall sample collection, with particularly one sample (#708) having strongly elevated Al_2O3 and SiO_2 for its average ilmenite. The same holds for grain length as illustrated in Fig. 6d, where the former narrow variation for high TiO_2 ilmenite samples is exceeded considerably for several samples.

There is only little garnet in sediment samples from the Chavara segment, but the composition of the few grains measured largely confirms the data from the 2002 sample collection, with low grossular and high pyrope components, illustrated in Fig. 9.

The along-coast variation of the TiO_2 content in average ilmenite is illustrated in Fig. 12, for samples of beach sediments, including the three 2002 samples #27-29. All samples have high TiO_2 in ilmenite varying between 59.8 wt.% (#706) and 62.4 wt.% (#714), with a mean of about 61 wt.% TiO_2. No systematic variation is apparent from these data on samples along the coast.

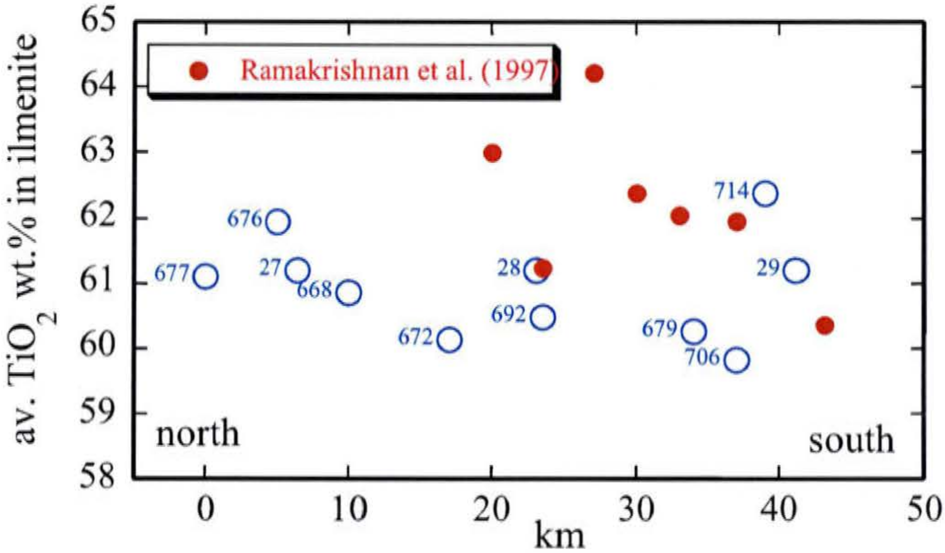
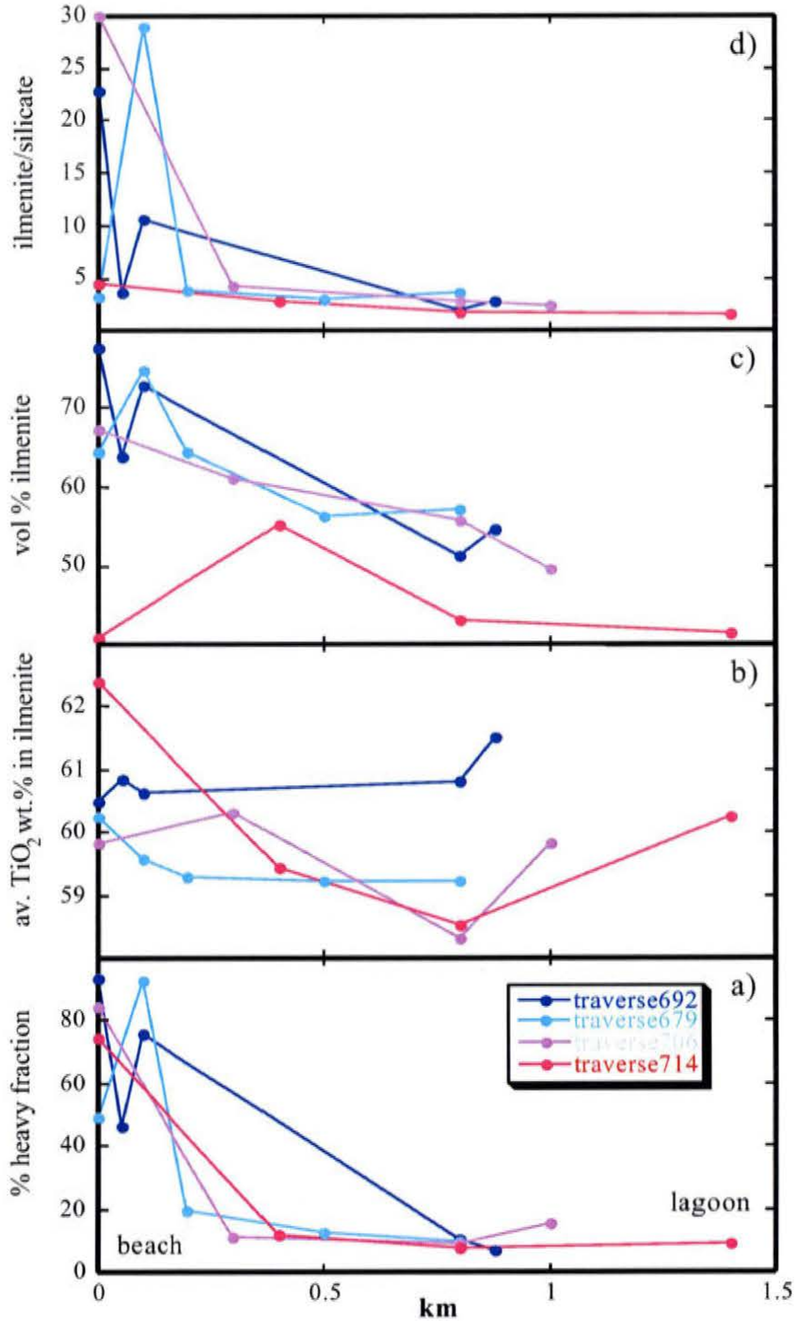


Figure 12

The sample traverses perpendicular to the coast line, on the other hand, yield some consistent patterns. In Fig. 13, each of the traverses are shown with a distinct colour, from traverse starting with sample #714 (referred to as traverse #714) in the south to the traverse #692 some 16 kilometers to the north (see Fig. 11). The data shows that samples from the beach zone have much higher proportions of the heavy mineral fraction (94%-47%) than the samples distal to the beach zone (Fig. 13a). The proportion of heavy minerals reaches a consistent low from about 300m from the beach zone and well into the lagoons, were the variation in this parameter is 7% to 20%, with an average of around 10% (by weight). This is followed by a weak tendency towards lower TiO_2 contents for samples away from the beach zone (Fig. 13b), which, however, is not seen in the northern traverse #692. Furthest away from the beach zone, on the inland side of the lagoon, three sample traverses show an increase in TiO_2 (Fig. 13b). Sample traverse #679 contains no sample from the inland side of the lagoon.



d)
c)
b)
a)
ilmenite/silicate
vol % ilmenite
av. TiO_2 wt.% in ilmenite
% heavy fraction
traverse692
traverse679
traverse714
lagoon
beach
km

Figure 13

The modal content of ilmenite decreases from about 70 vol. % (of the heavy mineral fraction) in the beach zone to about 55 vol. % in the lagoon zone, except the southernmost traverse #714 which has lower ilmenite content in all samples, and show no consistent lateral variation (Fig. 13c). These variations may be understood in terms of hydrodynamic sorting of the sediment, where the beach material is subject to constant reworking by wave action, which is very efficient in density sorting of sediments. The sediments in the lagoonal environment are subjected to considerably less energy and thus not only contain less of the heavy mineral fraction, but has a less fractionated heavy mineral assemblage, with a higher proportion of the heavy silicates with densities of around $3.5 g/cm^3$ compared to the 4.7-$4.7 g/cm^3$ for ilmenite, which is illustrated in Fig. 13d. The samples that diverge from this pattern, such as #714 and #29 (the latter not shown), contain relatively little ilmenite of about 40 vol.%, in spite of their high contents of heavy minerals, between 70% and 80%, and almost constant ilmenite/silicate ratios. One may speculate that lagoonal sediments recently was transported to the beach zone to supply the sediments, but such interpretations would need closer detailed studies.

In Fig. 14a and b is further illustrated the variation in average SiO_2 and Al_2O_3 of ilmenite for the samples of the four traverses. There are consistent increases in these two compositional parameters in all four traverses from the beach towards the lagoon. MgO shows little variation (not shown). If only considering the beach samples, then ilmenite from all four traverses fall within the compositional field outlined by the 2002 samples (Figs. 6b and 6c). In other words, samples distal to the beach zone are responsible for the strongly elevated SiO_2 and Al_2O_3, seen for the Chavara segment samples in Figs. 6b and 6c. There is no change in the potassium contents of the average ilmenite, so the increases in silica and aluminium cannot be a consequence of clay mineral impurities in the ilmenite. Rather, the increase is a result of mobilisation of chemical consituents in the sediment after deposition. Frost et al. (1983) found similar significant increases in aluminium and silica at the transition from pseudorutile (here referred to as high-Ti ilmenite) to leucoxene in sediments from Western Australia, and related such increases to impurities introduced to the grains during the bulk dissolution and reprecipitation leading to leucoxene formation.

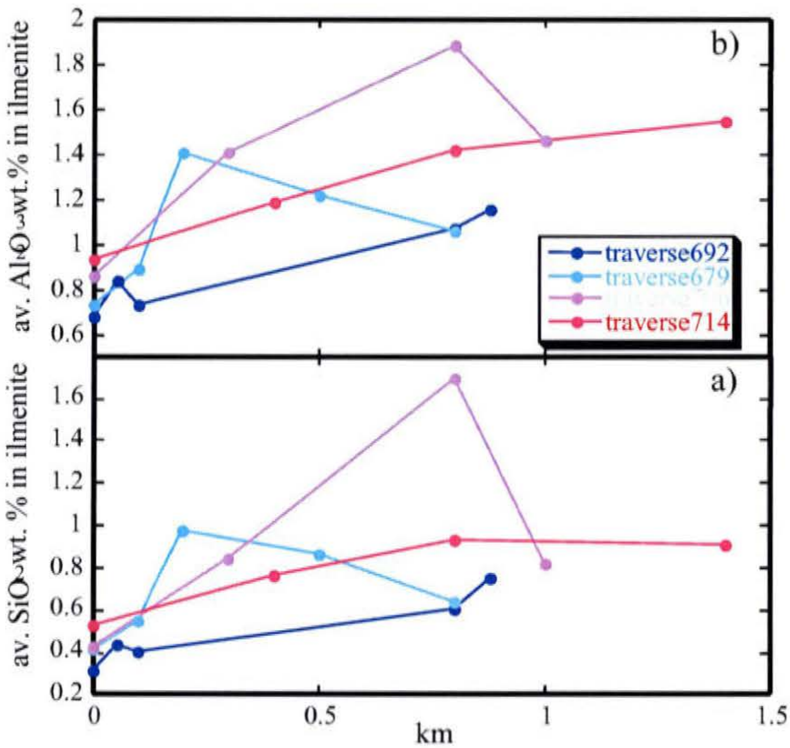


Figure 14

The observations presented above primarily demonstrate the continuity and compositional consistency of the Chavara deposits. In many respects, the present study confirms the findings of Ramakrishnan et al. (1997), who analysed ilmenite by wet chemistry on a series of samples from eight traverses similar to the DuPont/GEUS 2003 program, covering the coastal zone from Ashtamudi lagoon in the south to Kayamkulam lagoon in the north, at #28 (Fig. 11). Ramakrishnan et al. (1997) found no consistent lateral variation in TiO_2 within the beach samples, and their data are close to those obtained in this study (Fig. 12). In all their eight traverses, Ramakrishnan et al. found the samples on the inland side of the lagoons to have elevated TiO_2 in ilmenite when compared to particularly the western side of the lagoon, and often also compared to the beach samples. Even more distinct is the decrease in FeO of the ilmenite in samples from the beach and inland, while having relatively constant Fe_2O_3. Since the beach zone receives a constant supply of offshore material, it is speculated that the increase inland in TiO_2 and decrease in FeO in ilmenite is caused by progressive alteration in situ.

The southernmost traverse (about 2km south of our sample #29) close to the Ashtamudi lagoon, the TiO_2 of the ilmenite in samples away from the beach was considerably lower than any other of their samples. Ramakrishnan et al. (1997) explained this by referring to the proximity of the Kallada river bringing fresh sediment to the system, while the samples to the north of the Ashtamudi lagoon contain sediments reworked from offshore. This is accordance with the inference given above that the traverse #714 may contain fresh sediments, with less density-fractionated heavy minerals.

As concluding remarks, it can be stated that the Chavara deposit exhibit a high degree of homogeneity, which is consistent with the geological models referred to above, in which the source for the deposits are off shore shelf sediments, reworked by wave activity and deposited in the tidal and near tidal zone. Prolonged exposure to the humid climate in the areas inland from the lagoons further tends to alter the ilmenite and increase its TiO_2, SiO_2 and Al_2O_3 content while reducing FeO. To the beach-side of the lagoon, the lower TiO_2 in ilmenite, coupled with a lower heavy mineral content points to an environment which periodically is influenced by drifting sand and possibly marine wash-over during monsoon.

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REPORT ON SURFACE SAMPLING OF HEAVY MINERAL RICH SANDS IN THE COASTAL TRACT BETWEEN QUILON (KOLLAM) AND KAYANKULAM, WITH A NOTE ON THE OCCURRENCE OF HEAVY MINERAL RICH SANDS FURTHER NORTH UPTO THOTTAPALLI, KERALA

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2nd June 2003

(note: figures are available from Stefan Bernstein on request)

PREAMBLE

A previous literature survey by V.N.Vasudev and a reconnaissance field sampling study by M.Hanuma Prasad and V.N.Vasudev brought to the attention of Dr.Henrik Stendal of the Geological Survey of Denmark and Greenland, occurrence unusually titanium rich ilmenite sands near Chavara along the Arabian sea coast north of Quilon. Heavy mineral rich sands of this region have been supporting production of ilmenite, rutile, sillimanite, garnet and monazite by the Indian Rare Earth Ltd., Quilon, and Kerala Minerals and Metals Ltd., Quilon. These companies have been working on coastal sands well known as the Chavara Deposits. Dr.Stendal was interested to know the extension of these deposits along the coast and to understand the variation of heavy mineral abundance perpendicular to the coast line and also understand the TiO2 enrichment processes. He, therefore, requested Dr.V.N.Vasudev vide his letter dated February 10, 2003 whether such a study could be undertaken and the task of sampling accomplished. Vasudev discussed the sampling programme with Dr.R.Srinivasan and assigned the task of sampling to him. Srinivasan carried out the sampling between 25 April to 15 May 2003.

GEOMORPHIC SETTING

The areas chosen for sampling are between Kayakulam in the north (9°8'N; 76°28'E) and Neendakara in the south (8°56'N; 76°32'E). It was also desired to see, if there are further extensions of these deposits to the north. Hence observations and sampling were extended upto Thottapalli (9°19'N;15°23'E) ***(Fig.1)***.

The area between Kayankulam and Neendakara falls between two back water bodies called respectively as Kayankulam Kayal and Astamudi-Kayal. The two are connected by a canal which serves as a commercial water way. The coast parallel canal separates the sea shore from the rest of the coastal tract located about 500 m away from the shore line. A coast parallel road runs between the canal and the shore line roughly about 150 to 300m away from the shore. The coast parallel road is connected to the interior highways only by very few bridges, so that principal mode of transport is to use the ferry across the canal.

The coastal tract of Kerala is very thickly populated. The population density ranges from 1500 to 5000 per sq km. The original geomorphic features are strongly modified by agricultural activity, which is mainly coconut production ***(photograph 1)***. Coast parallel sand bars or dunes have thus been strongly modified. Some times coconut plantation and dwellings are just a few tens of meters from the high water level.

The shore line itself is strongly modified by erection of walls to prevent coastal erosion. Beaches open to the sea without these walls are far and few.

OCCURRENCE

Ilmenite rich sands occur right on the coast line close to the high water level ***(photograph 18)***. Here reworking in progress produces more than 60 to 70% rich heavy mineral sands that occur as 1 to 2 m thick top layer that is underlain by sands with centimeters thick ilmenite rich bands alternating with silica sand rich layers ***(photographs 9 & 16)***. The content of heavy minerals drops to < 50% within about 100 from the high water level and to < 25% beyond 150-200m. Indian Rare Earths Ltd., which is the principal producer of heavy minerals (monazite, garnet, sillimanite, ilmenite and rutile) carried out systematic grid sampling (at 500m intervals) upto a depth of 10m along and across the coast line in the area. Auger and reverse rotary drilling was adopted by them for sampling from depth. Modal analyses of representative samples led to the preparation of maps showing heavy mineral abandance pattern. The maps are classified information. For academic education, they are enclosed ***(Fig.2, 3, 4, 5)***. No permission has been given for their reproduction.

SAMPLING

In the present study sampling has been carried by pitting upto a depth of 1m on an average ***(photographs 3 ,6 & 17)***. The cubic metre size sample recovered from excavation was reduced to about 5 kg by coning and quartering ***(photograph 4)***. Sampling has been carried out along as well as across the coast line, the latter along a few profiles. Location of the samples are shown on the heavy mineral abundance maps prepared by the IRE ***(see Figs.2, 3, 4, 5) and in Fig.6.***

Sampling by pitting yields samples from near the surface. They have a limited depth of about 1m. Sampling especially close to the canal had some times to be restricted to a depth of 0.75 to 0.9 m as water table was met with. Therefore, the abundance of heavy minerals that may be obtained by these samples may not be the same as indicated by the maps prepared by the IRE which were prepared based on samples drawn up to 10 m depth. The mineral abundance obtained by the present set of samples would only be indicative of the nature of variation near the surface. There could be heavy mineral rich sands at depth which can only be ascertained by power auger or reverse rotary drilling.

Grid sampling could not be carried out as pitting was not always permissible in coconut plantations. Only where the land lords permitted, sampling pit could be sunk. Therefore, the distance between sampling sites along profiles perpendicular to the coast is variable. However, samples have been collected from all the abundance zones given in the IRE maps.

During the course of this work as new deposits not reported earlier between Kayankulam and Thottapalli Came to light sampling sampling along the coast between Kayankulam and Thottapalli was carried at about 8 sites. These samples would given an indication of the grade of these ilmenite rich sands.

SAMPLES

Most of the samples collected near the high water level have, in addition to ilmenite, other heavy minerals and calcareous shells. Those closer to the old strand lines about 25-50m away from HWL were found to be richer in siliceous sands relative to those near the HWL.

Bulk of the samples west of the coast parallel road, are of good grade as far as ilmenite is concerned, but the grade falls east of the road, as one proceeds eastward towards the canal. Near the canal and east of it, the sands are silty with a small amount of clay. These are rich in humus and other organic matter and have large number of roots ***(photograph 6)***. Pebbles of laterite probably derived from eastern lateritic terrane have been found. They could also be contaminants from the lateritic gravel used for road construction earlier. Wherever rock fragments like leptynites or khondalites are found in samples, they are fragments related to the stones used for construction of walls built to protect the coast.

Most of the samples as collected were wet. They have been air dried. During drying the more silty and clayey samples formed pellets, which to the extent possible were disintegrated by squeezing between fingers. However, some pellets could still be present.

LIST OF SAMPLES

AREA OF NEWLY REPORTED DEPOSITS IN KAYANKULAM-THOTTAPALLI SECTOR *(FIG.6)*

1. Near low waterline, Trikkunnapuza
1A. Near high-water line (HWL)
2. Between Mangalam Tura and Arattupuza, sample near HWL
2A. Location same as above, ~30m east of sample 2
3. WNW of Kallikattu Tura. Sample near High water line.
4. Nallinkkal, Near HWL
5. Ramancheri, near HWL
5A. Ramancheri, About 60m east northeast of sample 5
6. Perumpalli Tura, upper black sand rich layer (~30cm thick) near HWL.
6A. Average sample of $1m^3$ combining upper black sand rich in ilmenite, as well as lower layers richer in silica sand.
7. Pallippad Vadakkubhagam near HWL.
8, 8A. Thottapalli, to the south of the sluice. 8 near HWL, 8A near road.

The above deposits can be accessed by coast parallel road that bifurcates from NH-47 near the 434 km marker east of the sluice or by the road that goes from Nagarkulangara to Trikunnapuza.

AREA BETWEEN KAYANKULAM AND NEENDAKARA (Figs.2,3,4 & 5)

KAYAMKULAM-ALAPPAD SECTOR (Fig. 5)

9 Pandara Thuruthu, South of Panikkarkadavu bridge near HWL

9A Near coast parallel road, about half metre below the surface, ~40m east of HWL.

9B Near the temple (Velanthuruthu Subramanya temple) to the east of the road, ~170m east of HWL

9C About 130m west of the canal and 150m east of 9B.

9D Near the Canal.

(Samples 9 to 9D provide ~500m long profile. As samples 9C and 9D did not show black sands in 1m deep pits, profile sample was terminated here).

Area south of 9 is currently under production by IRE.

10 Black sand from HWL, Cheriazikkal

11 About a kilometer NNW of 10, HWL

12 Kayamkulam Kayal, fishing harbour area 30 cm thick ilmenite rich layer at the HWL

12A Average sample of $1m^3$ volume from the same site as 12

12B 100m from the HWL

12C Near the coastal erosion protection wall, old stand line.

13 Azheekal Vadaxku, HWL to the west of the road from near HWL

14 Azeekal upper 70 cm black heavy mineral rich strand layer.

14A 70cm-1.25m layer, mixed black and white sand.

14B 28m east of 14A and B

14C Ayiranthengu east of the canal.

14D Island between Ayiranthengu and canal

15 Srayikkattu near Avani junction, sample from HWL

16 Parayakkadavu, opposite Amiratnnandamayi Ashram HWL

16B East of the coast parallel road, about 30m from Amritanandamayi Ashram

17 Alappad. HWL opposite Corporation Bank building.

17A Alappad, east of coast parallel road and on the western side of the canal to the west of Kakkathuruthu island.

17B Kakkathuruthu island, central part, to the east of the canal.

PANMANA SECTOR (Fig.4)

19 To the east of the Canal north of Kovilthottam

19A Thattambra Road to the north of Sankarmangalam Kovilthottam road

19B Immediately north of Chavara Police Station on NH-47. Police Inspector's premises.

20 West of Pallicheri Mukku near the HWL

20A To the west of the Canal about 250m away from the coast

20B Midway between Pallicheri Mukku and Koprayil Mukku

20C Chittur Panmana West of KMML on NH-47

21 Neendakara Azi, Fishing harbour area, Saktikulangera

CHAVARA SECTOR (Fig.3)

18	Kovilthottam to the north of KMML workings.
18A	Chericheribhagam from the IRE workers colony
18B	Thattasseri, to the west of NH.47, 13.5km from Kollam
22	Light house premises west of Nallezhath Mukku
22A	Kulangaratha Bhagam, IRE colony, E of canal
22B	Chericheribhagam mid way between NH47 and Kulangaratha Bhagam
22C	East of Pananthodil junction, Chavara

NEENDAKARA SECTOR (Fig. 2)

23	Edathuruthu to the west of the canal.
23A	Edathuruthu island to the east of the Canal.
24	Neendakara near the coastal erosion protection wall behind the fishing port
24A	100m east of 24 and just west of beach road
25	Neendankara, near HWL west of NH-7
25A	About 100m north of the junction between beach road and NH-47, Neendakara
25B	To the east of NH-47, about 40m east of 25A
26	Near the coast line at Putenthura – west of NH-47
26A	To the east of NH-47, ~50m from the road.

ACKNOWLEDGEMENTS: Discussions with Dr. T.N. Prakash and Dr. Narayana swamy of the Center of Earth Science Studies in Trivandrum were very useful in evolving prospecting strategy. The logistic help given by Prof. A.C. Narayana of the Dept. of Oceanography, Cochin University is greatly appreciated. The Maps were digitized and formatted in Mapinfo by K.N. Prasad, CAD Engineer, Bangalore. We thank him for his efficient service.

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CAPTION TO PHOTOGRAPHS

1& 2: View of the black sands looking south along the coast near Perumballi village; 9°10';76°23'

3. View of a pit from which sand sample is extracted. Shows thick black sand layer near the top of the pit (view looking east), Perumballi.

4. About 1m^3 of sand being built as a cone for mixing, coning and quartering, Perumballi.

5 About 30m from the HWL inland, black sands are interlayered with white silica sands almost upto 50%, Perumballi village.

6 60m east of the pit at the HWL, Perumballi. Coconut groves are common. Roots of Coconut palms can be seen.

7 View of Kayamkulam Kayal near Perumpalli. Looking south.

8 Black sands with a thin veneer of white sand near HWL, near Vattachal.

9 Near Mangalam Tura(Loc.2) more than a metre thick black sand overlying black sands interlayered with white sand. View in a pit looking E.

10 --------- " ---------

11 South of the sluice near Thottapalli where sand deposits are widest. Looking South.

12 -- Do --; Looking north

13 -- Do --, Panoromic view of Thottapalli Sluice

14 Thick black sand accumulation on the sea coast near Kayamkulam fishing harbour, looking South.

15 -- " --, closer view. Looking South.

16 Nearly half metre to three fourth meter thick black sand constitute black sands of the top layer, Kayamkulam fishing harbour area.

17 Pit being excavated for sample extraction, Kayamkulam fishing harbour area, Alapattu Village.

18 Thick layer of black sand, HWL, Kayamkulam fishing harbour area.

20 Details Neendakara coast.

22 Sorting of sands by waves. Wave ripples excellently developed. Waves recede to the right depositing ilmenite rich sands to the left and monazite and silica sands to the right, Neendakara coast.

23 Ripple marked sands in vertical section show layered black and greenish white sands. Key for scale 5 cm long.

24 -- Do --

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Subject: Sampling of Heavy Mineral Sands along the Kerala Coast

Statement of Expenditure incurred by Dr. V.N.Vasudev, Geological Consultant, Bangalore

Advance received (As per the Bank statement)			**Rs.135,151**
I	**Lodging**		**Rupees**
	27.04.03	Cochin Univ. Guest House	400.00
	28.04.03	Hotel Ambalakkara, Kollam	692.00
	08.04.03	Hotel Sudarshan, Kollam	10,500.00
	09.05.03	Gauri Nivas, Trivandrum	846.00
	11.05.03	Cochin Univ., Guest House	300.00
		Sub-Total	**12,738.00**
II	**Vehicle hire**		
	14.05.03	To Navya Cabs, Bangalore	30,175.00
	30.05.03	To Navya Cabs, Bangalore	875.00
	15.04.03	To Car city	200.00
		Sub-Total	**31,250.00**
III	**Stationery and Materials**		
	21.04.03	Polythene bags	110.00
	21.04.03	Polythene bags	125.00
	21.04.03	Kora Cloth for sample bags	1,400.00
	21.04.03	Stationary (marker pens etc.)	570.00
	22.04.03	Stationery (Kerala road maps etc.)	135.00
	28.04.03	Photographic film	110.00
	30.04.03	Stationery, tracing film etc.	128.00
	02.05.03	Stationery, tracing film etc.	135.00
	21.05.03	Photographs: developing and printing (2 sets), (2 vouchers)	441.05
	30.05.03	Metal Trunks (4 Nos.) for dispatching samples. (only one voucher for Rs.900/-)	1,200.00
		Sub-Total	**4,354.05**
IV	**Services**		
	25.04.03	Cloth bag stiching charges	800.00
	07.05.03	Labour charges for 10 days @ Rs.300/- day for two labourers	3000.00
	26.04.03	Xeroxing of topos, maps, reprints	1120.00
	-	Telephone charges to Bangalore, Cochin, Trivandrum etc.	657.12
	-	Road toll, parking etc.	28.50
		Sub-Total	**5,605.00**

Brought forward..		**53,947.00**
V	**Food, water etc.** @ an average of Rs.600/- day for 16 days from 25.4.03 to 11.5.03 (as admissible)	9,600.00
VI	Postage (Reprints & maps, vouchers and statement of expenditure to GEUS Denmark)	600.00
VII	Map digitization, printing, report typing etc.	5,000.00
VIII	Consultancy fee (for two) and payments to Scientists/Geologists in Kerala	40,000.00
	Sub-Total	**55,200.00**
IV	Sample despatch to Henrik Stendal, Air Cargo Charges	42,696.00
Grand Total:		**151,843.00**
Money already received from Dr.Henrik Stendal, GEUS		1,35,151.00
Balance due from GEUS		**16,692.00**

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Geological Survey of Denmark and Greenland
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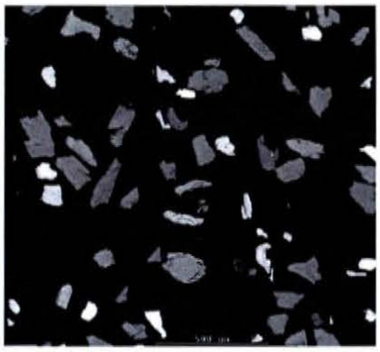
GEUS

Sample Name:		No. of frames analysed	89
Lab. Name:	2000220	No. of particles analysed:	780
Date:	10-04-03	Heavy minerals in raw sand (%):	0,00
Submitter:	H Stendal	Comments:	
Country:			
Analyzed by:	JK		
Acc. Voltage/Magnification: 17kV/60x			
Guard region:	280 μm		
Sieve:	100 μm²		



	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	50,5	44,1	1,7	0,1	1,0	0,6	0,5	0,1	0,2	98,7
Leucoxene	77,8	15,8	0,4	0,4	1,1	2,3	0,4	0,3	0,2	98,4
Rutile	95,5	1,2	0,0	0,0	0,3	0,2	0,1	0,1	0,4	97,8
Ti magnetite	34,8	55,8	0,9	0,2	3,6	0,8	0,7	0,3	0,4	97,6
Magnetite	0,9	93,0	0,1	0,3	1,5	1,1	0,3	0,4	0,3	97,9
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	0,1	0,5	0,1	0,0	0,6	0,0	0,0	57,3	1,4	60,1
Monazite	0,0	0,6	0,0	0,0	3,0	0,9	0,3	1,5	3,5	9,7
Y-phosphate	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Sphene	38,2	2,0	0,0	0,2	29,5	1,5	0,1	27,4	0,0	98,9
Garnet	0,4	26,8	1,1	0,1	38,8	17,6	5,2	7,7	0,2	98,0
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	1,1	0,1	0,1	29,9	0,3	0,2	0,1	63,9	95,9
Silicate	1,5	18,1	0,4	0,2	46,7	8,5	11,0	9,8	0,1	96,3
Unclassified	5,1	13,1	0,6	0,6	11,9	2,4	2,5	29,7	6,6	72,5

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	40,6	1,6	1,2	23,5	24,4	8,8	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%	51,1	79,0	97,6	35,7
Fe_2O_3 wt%	44,7	16,0	1,3	57,2
MnO wt%	1,7	0,4	0,0	0,9
Cr_2O_3 wt%	0,1	0,4	0,0	0,2
SiO_2 wt%	1,0	1,1	0,3	3,7
Al_2O_3 wt%	0,6	2,3	0,2	0,9
MgO wt%	0,6	0,4	0,1	0,7
CaO wt%	0,1	0,3	0,1	0,3
ZrO_2 wt%	0,2	0,2	0,4	0,4
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	47,2
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	46,3
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	9,4	
Leucoxene	0,4	
Rutile	0,3	
Ti magnetite	5,4	
Magnetite	7,6	
Chromite	0,0	
Pyrite	0,0	
Phosphate	2,5	
Monazite	0,5	
Y-phosphate	0,0	
Sphene	1,2	
Garnet	5,6	
Kya/Sill	0,0	
Staurolite	0,0	
Zircon	2,0	
Silicate	60,5	
Unclassified	4,8	
Total	100,0	

Geological Survey of Denmark and Greenland
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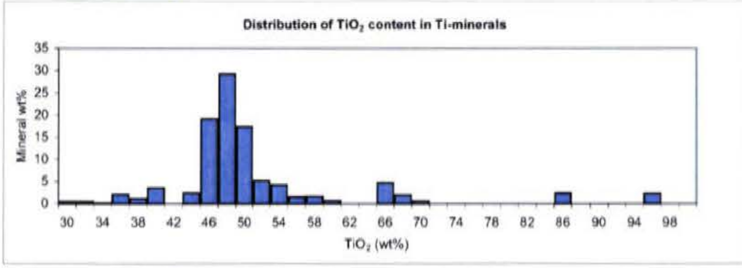
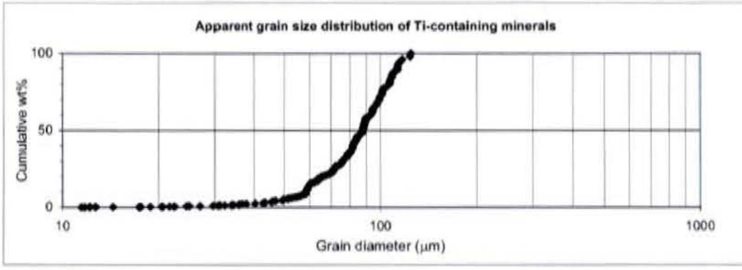
GEUS

Lab. Name:	2000220	Analyzed by:	JK
Submitter:	H Stendal	Acc. Voltage	17kV
Date:	10-04-03		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,7	1,7	292	111	4311	89
Leucoxene	1,7	1,6	359	128	7388	2
Rutile	1,4	1,8	344	132	5241	2
Ti magnetite	1,7	1,7	268	103	3870	54
Magnetite	1,5	1,7	269	100	3878	69
Chromite	0,0	0,0	0	0	0	0
Pyrite	0,0	0,0	0	0	0	0
Phosphate	1,5	1,8	536	202	13292	7
Monazite	1,6	1,5	251	88	3319	5
Y-phosphate	0,0	0,0	0	0	0	0
Sphene	1,4	2,9	1050	455	30735	2
Garnet	1,8	2,0	361	146	5757	45
Kya/Sill	0,0	0,0	0	0	0	0
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,6	1,5	242	82	3651	22
Silicate	1,8	2,1	486	197	10207	412
Unclassified	1,5	2,0	413	169	8317	39

Geological Survey of Denmark and Greenland
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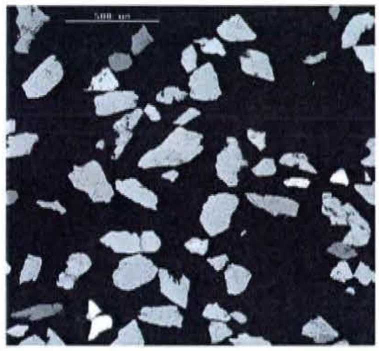
GEUS

Sample Name:		No. of frames analysed	32
Lab. Name:	2000225	No. of particles analysed:	734
Date:	16-04-03	Heavy minerals in raw sand (%):	0,00
Submitter:	H. Stendal	Comments:	
Country:			
Analyzed by:	JK		
Acc. Voltage/Magnification: 17kV/50x			
Guard region:	325 μm		
Sieve:	100 μm²		



	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	52,1	41,1	1,7	0,1	1,3	1,2	0,7	0,3	0,2	98,6
Leucoxene	72,5	12,0	0,8	0,2	4,8	4,2	0,9	1,5	0,2	97,1
Rutile	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Ti magnetite	36,7	54,1	1,4	0,3	2,9	0,8	1,0	0,3	0,2	97,7
Magnetite	0,0	74,1	11,6	0,2	0,6	0,7	3,5	7,8	0,4	98,9
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	0,1	0,6	0,1	0,0	0,6	0,0	0,1	56,6	1,5	59,6
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	37,8	2,9	0,0	0,1	27,9	2,0	0,3	25,3	0,0	96,3
Garnet	0,5	22,9	0,6	0,1	41,0	16,6	6,6	8,9	0,2	97,3
Kya/Sill	0,1	0,7	0,1	0,2	42,8	53,6	0,0	0,0	0,3	97,9
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,4	0,5	0,1	0,4	29,3	0,2	0,1	0,1	63,7	94,8
Silicate	1,1	16,5	0,4	0,2	47,1	11,2	11,0	8,8	0,1	96,5
Unclassified	1,6	10,9	0,4	1,2	18,9	2,1	4,2	44,0	6,5	89,8

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	25,2	2,4	0,0	14,3	54,6	0,8	2,6	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	52,8	74,7	0	37,6
Fe_2O_3 wt%	41,7	12,4	0	55,4
MnO wt%	1,7	0,8	0	1,4
Cr_2O_3 wt%	0,1	0,2	0	0,3
SiO_2 wt%	1,4	5,0	0	3,0
Al_2O_3 wt%	1,2	4,3	0	0,8
MgO wt%	0,7	0,9	0	1,0
CaO wt%	0,3	1,5	0	0,3
ZrO_2 wt%	0,2	0,2	0	0,2
Total	100,0	100,0	0	100,0

Average TiO_2 content of all the TiO_2 minerals:	48,9
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	48,9
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	4,9	
Leucoxene	0,5	
Rutile	0,0	
Ti magnetite	2,8	
Magnetite	0,8	
Chromite	0,0	
Pyrite	0,0	
Phosphate	1,1	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,1	
Garnet	10,7	
Kya/Sill	0,5	
Staurolite	0,0	
Zircon	0,2	
Silicate	75,6	
Unclassified	2,9	
Total	100,0	

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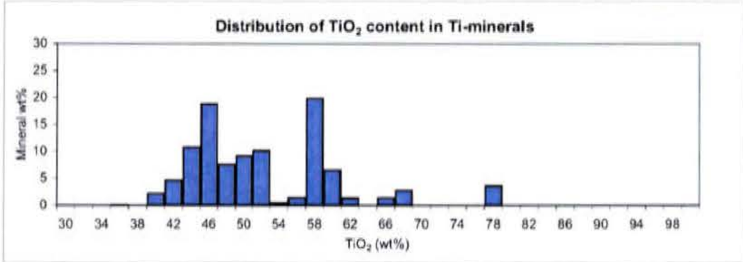
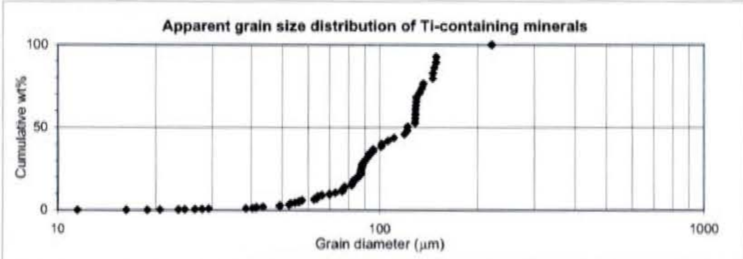
Lab. Name:	2000225	Analyzed by:	JK
Submitter:	H. Stendal	Acc. Voltage	17kV
Date:	16-04-03		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm^2)	Total grains
Ilmenite	1,6	1,6	358	131	7537	42
Leucoxene	1,6	1,8	582	221	15367	2
Rutile	0,0	0,0	0	0	0	0
Ti magnetite	1,8	1,7	311	118	5306	32
Magnetite	2,0	2,0	1056	422	44609	1
Chromite	0,0	0,0	0	0	0	0
Pyrite	0,0	0,0	0	0	0	0
Phosphate	1,3	1,7	454	168	10958	6
Monazite	0,0	0,0	0	0	0	0
Y-phosphate	0,0	0,0	0	0	0	0
Sphene	1,7	2,1	475	193	8579	1
Garnet	1,8	2,0	477	191	10727	72
Kya/Sill	1,3	1,5	306	110	6562	7
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,4	1,3	237	71	3351	3
Silicate	1,7	1,9	536	214	14927	554
Unclassified	2,2	2,6	808	360	22125	14

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GEUS

Sample Name:		No. of frames analysed	32
Lab. Name:	2000227	No. of particles analysed:	759
Date:	22-04-03	Heavy minerals in raw sand (%):	0,00
Submitter:	H. Stendal	Comments:	
Country:			
Analyzed by:	JK		
Acc. Voltage/Magnification: 17kV/40x			
Guard region:	330 µm		
Sieve:	100 µm^2		

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	60,4	35,3	0,5	0,2	0,4	0,8	0,9	0,1	0,2	98,7
Leucoxene	72,7	22,0	0,3	0,3	0,6	1,7	0,8	0,1	0,2	98,6
Rutile	95,4	1,2	0,2	0,3	0,3	0,5	0,1	0,0	0,4	98,4
Ti magnetite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
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	0,1	0,0	0,0	2,7	0,3	0,1	3,5	6,3	12,9
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	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Kya/Sill	0,2	0,5	0,1	0,3	42,8	54,3	0,0	0,1	0,1	98,3
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,4	0,5	0,1	0,1	29,5	0,1	0,1	0,1	65,1	96,1
Silicate	0,2	0,3	0,1	0,2	49,0	48,6	0,0	0,0	0,1	98,4
Unclassified	22,8	11,4	0,4	2,0	18,2	16,4	0,9	0,1	19,0	91,2

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	82,8	11,7	2,3	0,0	0,0	1,7	1,4	0,0	100,0

	Normalised average contents of the valuable Ti-containing minerals:			
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	61,2	73,7	97,0	0
Fe_2O_3 wt%	35,7	22,3	1,2	0
MnO wt%	0,5	0,3	0,2	0
Cr_2O_3 wt%	0,2	0,3	0,3	0
SiO_2 wt%	0,4	0,6	0,4	0
Al_2O_3 wt%	0,8	1,7	0,5	0
MgO wt%	0,9	0,8	0,1	0
CaO wt%	0,1	0,1	0,0	0
ZrO_2 wt%	0,2	0,2	0,4	0
Total	100,0	100,0	100,0	0

Average TiO_2 content of all the TiO_2 minerals:	63,6
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	62,8
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
	Heavy mineral concentrate	Raw sand
Category	wt %	wt %
Ilmenite	80,2	
Leucoxene	11,4	
Rutile	2,2	
Ti magnetite	0,0	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,1	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,0	
Kya/Sill	1,4	
Staurolite	0,0	
Zircon	1,7	
Silicate	2,6	
Unclassified	0,5	
Total	100,0	

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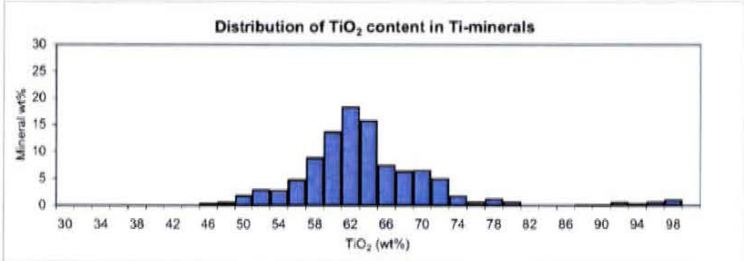
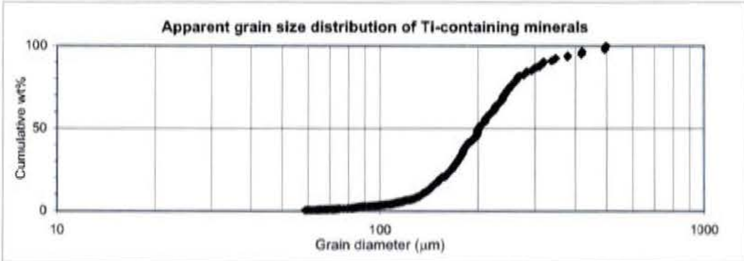
GEUS

Lab. Name:	2000227	Analyzed by:	JK
Submitter:	H. Stendal	Acc. Voltage	17kV
Date:	22-04-03		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (μm^2)	Total grains
Ilmenite	1,6	1,7	670	253	23572	592
Leucoxene	1,6	1,7	648	242	24118	82
Rutile	1,7	1,7	573	212	17182	20
Ti magnetite	0,0	0,0	0	0	0	0
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	1,6	1,4	345	123	7591	3
Y-phosphate	0,0	0,0	0	0	0	0
Sphene	0,0	0,0	0	0	0	0
Garnet	0,0	0,0	0	0	0	0
Kya/Sill	1,4	1,9	880	338	42109	8
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,5	1,6	418	151	10566	27
Silicate	1,6	1,9	825	328	34708	22
Unclassified	1,4	2,3	828	356	26229	5

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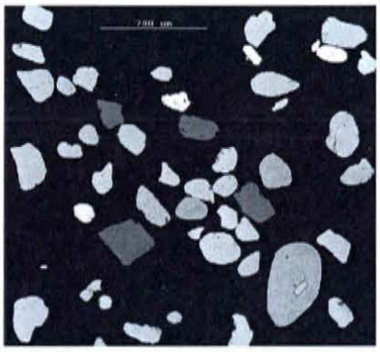
GEUS

Sample Name:		No. of frames analysed	39
Lab. Name:	2000228	No. of particles analysed:	685
Date:	23-04-03	Heavy minerals in raw sand (%):	0,00
Submitter:	H. Stendal	Comments:	
Country:			
Analyzed by:	EAN		
Acc. Voltage/Magnification: 17kV/40x			
Guard region:	340 µm		
Sieve:	100 µm²		



	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	60,5	35,3	0,5	0,2	0,4	0,7	0,9	0,1	0,2	98,8
Leucoxene	73,0	20,5	0,3	0,2	1,3	2,2	0,8	0,2	0,2	98,7
Rutile	95,4	0,9	0,2	0,2	0,3	0,4	0,1	0,1	0,4	98,0
Ti magnetite	40,5	48,3	1,1	0,0	0,3	6,5	1,2	0,0	0,1	98,0
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	0,6	0,0	0,0	3,8	1,0	0,5	2,7	4,2	12,8
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	0,2	32,8	0,7	0,2	37,5	19,7	7,4	0,7	0,0	99,4
Kya/Sill	0,2	0,5	0,1	0,1	42,8	53,8	0,0	0,0	0,1	97,6
Staurolite	0,4	12,0	0,2	0,1	37,3	44,1	3,1	0,1	0,0	97,5
Zircon	0,3	0,5	0,1	0,1	29,6	0,0	0,1	0,1	65,0	95,8
Silicate	0,1	0,4	0,1	0,2	45,6	50,6	1,1	0,0	0,1	98,2
Unclassified	5,2	8,5	2,4	2,7	7,5	24,4	6,2	1,2	11,3	69,3

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	80,7	8,0	4,8	0,4	0,1	4,0	1,6	0,4	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	61,2	74,0	97,4	41,4
Fe_2O_3 wt%	35,8	20,7	1,0	49,2
MnO wt%	0,5	0,3	0,2	1,1
Cr_2O_3 wt%	0,2	0,2	0,2	0,0
SiO_2 wt%	0,4	1,3	0,4	0,3
Al_2O_3 wt%	0,7	2,2	0,4	6,7
MgO wt%	0,9	0,8	0,1	1,2
CaO wt%	0,1	0,2	0,1	0,0
ZrO_2 wt%	0,2	0,2	0,4	0,1
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	64,1
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	62,3
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	76,4	
Leucoxene	7,6	
Rutile	4,6	
Ti magnetite	0,4	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,2	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,1	
Kya/Sill	1,5	
Staurolite	0,4	
Zircon	3,7	
Silicate	4,9	
Unclassified	0,2	
Total	100,0	

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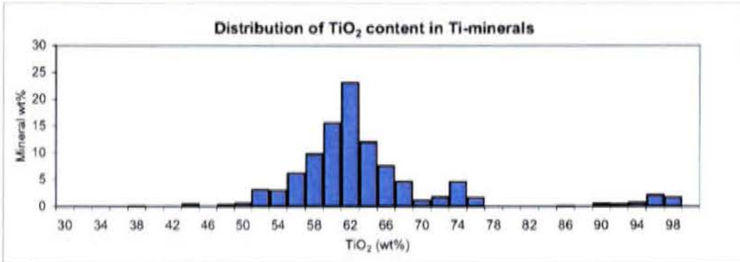
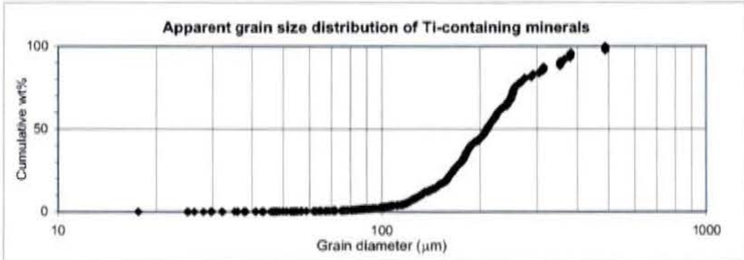
GEUS

Lab. Name:	2000228	Analyzed by:	EAN
Submitter:	H. Stendal	Acc. Voltage	17kV
Date:	23-04-03		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,5	1,7	708	264	26056	480
Leucoxene	1,6	1,7	672	252	28211	44
Rutile	1,5	1,6	487	180	14365	47
Ti magnetite	2,2	1,9	694	257	29755	2
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	1,6	1,3	300	104	6772	5
Y-phosphate	0,0	0,0	0	0	0	0
Sphene	0,0	0,0	0	0	0	0
Garnet	2,8	3,1	619	274	9747	2
Kya/Sill	1,9	2,6	773	319	24165	14
Staurolite	1,2	1,9	521	205	12061	6
Zircon	1,4	1,6	569	205	18545	32
Silicate	1,6	2,1	863	357	33360	41
Unclassified	1,4	1,2	209	81	5558	12

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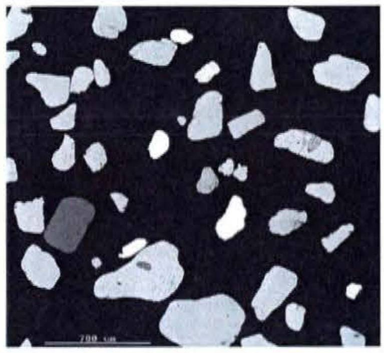
GEUS

Sample Name:		No. of frames analysed	46
Lab. Name:	2000230	No. of particles analysed:	653
Date:	02-05-03	Heavy minerals in raw sand (%):	0,00
Submitter:	H. Stendal	Comments:	
Country:			
Analyzed by:	EAN		
Acc. Voltage/Magnification: 17kV/40x			
Guard region:	325 μm		
Sieve:	100 μm²		



	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	58,2	37,1	0,4	0,2	0,6	0,8	0,9	0,1	0,4	98,6
Leucoxene	73,4	19,6	0,3	0,2	1,4	2,2	0,8	0,1	0,1	98,2
Rutile	94,9	0,9	0,1	0,1	0,4	0,3	0,1	0,0	0,6	97,4
Ti magnetite	42,4	39,2	0,2	0,1	1,1	0,6	0,9	0,4	0,5	85,4
Magnetite	5,1	86,9	0,3	0,0	2,6	3,0	0,4	0,1	0,3	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	1,0	0,0	0,0	3,8	0,7	0,6	4,0	5,7	15,8
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	0,1	31,1	0,4	0,0	37,6	20,4	8,3	0,7	0,1	98,7
Kya/Sill	0,4	0,9	0,1	0,2	42,5	53,4	0,0	0,1	0,4	98,0
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,4	0,5	0,1	0,1	29,6	0,1	0,1	0,1	65,2	96,1
Silicate	3,0	5,0	0,0	0,1	49,4	40,3	0,1	0,1	0,2	98,2
Unclassified	7,8	8,4	1,5	1,4	11,4	6,9	3,8	6,0	13,2	60,5

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	79,3	3,0	1,7	1,0	0,6	13,6	0,9	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	59,0	74,8	97,5	49,7
Fe_2O_3 wt%	37,6	20,0	0,9	45,9
MnO wt%	0,4	0,3	0,1	0,2
Cr_2O_3 wt%	0,2	0,3	0,1	0,1
SiO_2 wt%	0,6	1,4	0,4	1,2
Al_2O_3 wt%	0,8	2,3	0,4	0,7
MgO wt%	0,9	0,8	0,1	1,1
CaO wt%	0,1	0,1	0,0	0,4
ZrO_2 wt%	0,4	0,1	0,6	0,6
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	60,2
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	59,4
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	73,0	
Leucoxene	2,7	
Rutile	1,5	
Ti magnetite	0,9	
Magnetite	0,7	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	2,4	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,6	
Kya/Sill	0,8	
Staurolite	0,0	
Zircon	12,6	
Silicate	2,4	
Unclassified	2,3	
Total	100,0	

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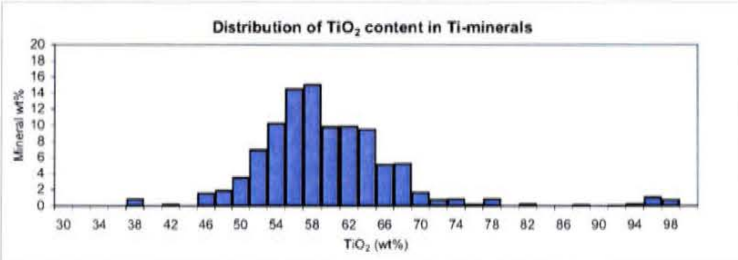
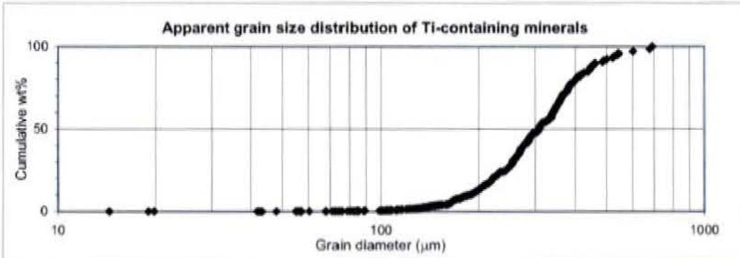
Lab. Name:	2000230	Analyzed by:	EAN
Submitter:	H. Stendal	Acc. Voltage	17kV
Date:	02-05-03		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,5	1,9	1029	398	51539	451
Leucoxene	1,5	1,9	1162	457	62291	14
Rutile	1,9	1,8	803	311	36440	12
Ti magnetite	1,7	2,4	1263	530	68260	4
Magnetite	1,4	1,7	1091	407	59981	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	1,6	1,6	826	304	38739	18
Y-phosphate	0,0	0,0	0	0	0	0
Sphene	0,0	0,0	0	0	0	0
Garnet	1,7	2,8	1545	666	69539	3
Kya/Sill	1,4	1,8	1546	584	116257	3
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,4	1,8	989	373	55301	70
Silicate	1,5	2,3	1771	727	119177	11
Unclassified	1,3	1,5	440	182	19330	64

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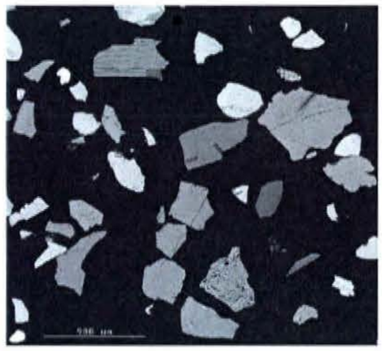
GEUS

Sample Name:		No. of frames analysed	33
Lab. Name:	2000233	No. of particles analysed:	782
Date:	05-05-03	Heavy minerals in raw sand (%):	0,00
Submitter:	H. Stendal	Comments:	
Country:			
Analyzed by:	EAN		
Acc. Voltage/Magnification: 17kV/30x			
Guard region:	400 µm		
Sieve:	100 µm²		



	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	51,5	42,5	0,6	0,1	1,3	1,5	0,9	0,1	0,2	98,6
Leucoxene	71,6	12,2	0,2	0,1	7,2	6,0	0,3	0,1	0,3	98,0
Rutile	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Ti magnetite	34,8	56,1	0,6	0,2	3,4	2,0	1,0	0,1	0,2	98,4
Magnetite	0,8	82,7	0,3	0,2	7,1	5,4	0,6	0,4	0,3	97,8
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	0,4	0,0	0,0	2,0	0,3	0,5	2,6	6,6	12,4
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	0,2	31,4	0,9	0,1	37,7	19,8	6,8	1,1	0,2	98,3
Kya/Sill	0,1	1,0	0,1	0,2	42,7	53,6	0,0	0,1	0,1	97,8
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,1	0,0	0,0	0,1	29,6	0,0	0,1	0,1	66,1	96,1
Silicate	1,0	15,4	0,4	0,1	46,1	25,6	7,0	1,1	0,2	96,9
Unclassified	7,5	33,3	1,0	0,5	23,9	16,0	3,4	0,8	3,2	89,6

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	16,9	0,9	0,0	18,1	62,4	0,1	1,6	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	52,2	73,0	0	35,3
Fe_2O_3 wt%	43,1	12,4	0	57,0
MnO wt%	0,6	0,2	0	0,6
Cr_2O_3 wt%	0,1	0,1	0	0,2
SiO_2 wt%	1,4	7,4	0	3,5
Al_2O_3 wt%	1,5	6,1	0	2,0
MgO wt%	0,9	0,3	0	1,0
CaO wt%	0,1	0,1	0	0,1
ZrO_2 wt%	0,2	0,3	0	0,2
Total	100,0	100,0	0	100,0

Average TiO_2 content of all the TiO_2 minerals:	44,3
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	44,3
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	14,1	
Leucoxene	0,8	
Rutile	0,0	
Ti magnetite	15,1	
Magnetite	1,4	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,1	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	52,0	
Kya/Sill	1,3	
Staurolite	0,0	
Zircon	0,1	
Silicate	11,3	
Unclassified	3,9	
Total	100,0	

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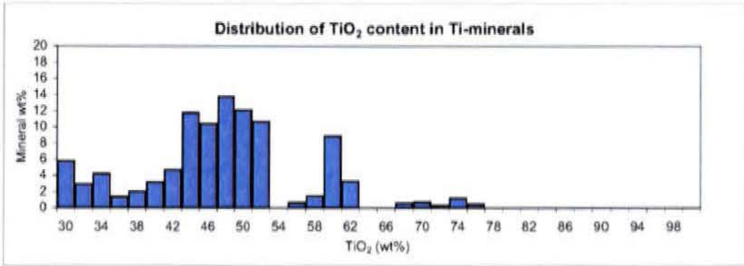
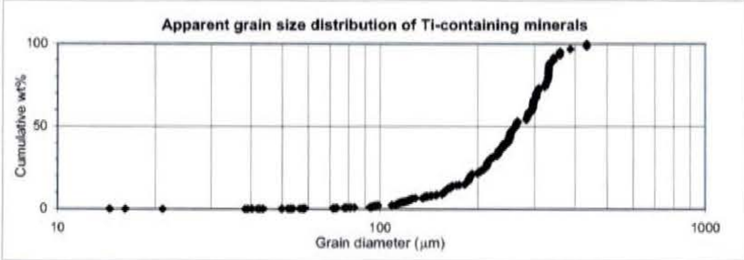
Lab. Name:	2000233	Analyzed by:	EAN
Submitter:	H. Stendal	Acc. Voltage	17kV
Date:	05-05-03		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm^2)	Total grains
Ilmenite	1,6	1,8	803	314	33420	126
Leucoxene	1,5	1,7	635	239	21356	11
Rutile	0,0	0,0	0	0	0	0
Ti magnetite	1,5	2,0	905	358	36871	115
Magnetite	1,6	1,5	529	201	21222	17
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	1,7	1,8	411	158	7466	4
Y-phosphate	0,0	0,0	0	0	0	0
Sphene	0,0	0,0	0	0	0	0
Garnet	1,7	2,1	1093	447	58528	298
Kya/Sill	1,6	1,8	705	266	25791	21
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,2	1,6	563	205	15653	1
Silicate	1,6	1,8	815	320	40673	141
Unclassified	1,5	2,0	1024	429	54874	35

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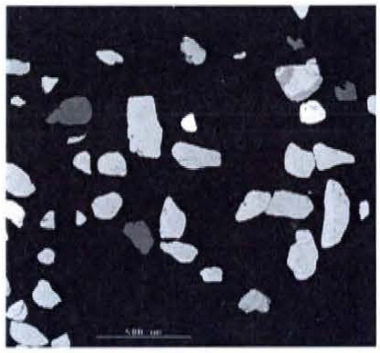
GEUS

Sample Name:	
Lab. Name:	2000238
Date:	06-05-03
Submitter:	H. stendal
Country:	
Analyzed by:	JK
Acc. Voltage/Magnification:	17kV/50x
Guard region:	250 μm
Sieve:	100 μm^2

No. of frames analysed	28
No. of particles analysed:	654
Heavy minerals in raw sand (%):	0,00
Comments:	



	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	58,4	36,1	0,5	0,1	0,9	1,2	1,0	0,1	0,4	98,7
Leucoxene	75,1	15,7	0,2	0,4	2,6	3,1	1,0	0,2	0,2	98,4
Rutile	95,1	1,0	0,2	0,1	0,3	0,4	0,1	0,0	0,4	97,7
Ti magnetite	40,1	28,3	0,5	0,2	9,2	7,0	0,9	0,1	9,1	95,4
Magnetite	3,3	62,9	0,3	0,4	12,8	12,6	2,1	0,5	0,3	95,2
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	0,5	0,0	0,0	2,6	0,5	0,1	3,1	5,6	12,4
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	0,2	33,7	0,5	0,1	37,6	19,6	5,8	0,7	0,1	98,3
Kya/Sill	0,2	0,8	0,1	0,2	42,8	53,6	0,0	0,0	0,1	98,0
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,2	0,3	0,1	0,1	29,5	0,1	0,1	0,1	65,5	95,8
Silicate	0,5	0,7	0,1	0,2	45,9	51,0	0,0	0,0	0,1	98,5
Unclassified	12,8	18,9	0,2	0,1	17,5	19,9	1,7	1,5	9,9	82,6

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	73,8	4,5	2,5	2,9	1,4	5,2	9,6	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	59,2	76,3	97,4	42,1
Fe_2O_3 wt%	36,5	15,9	1,0	29,6
MnO wt%	0,6	0,2	0,2	0,5
Cr_2O_3 wt%	0,1	0,4	0,1	0,2
SiO_2 wt%	0,9	2,6	0,3	9,7
Al_2O_3 wt%	1,2	3,2	0,4	7,3
MgO wt%	1,0	1,0	0,1	1,0
CaO wt%	0,1	0,2	0,0	0,1
ZrO_2 wt%	0,4	0,2	0,4	9,6
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	60,7
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	59,6
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	60,5	
Leucoxene	3,7	
Rutile	2,1	
Ti magnetite	2,4	
Magnetite	1,9	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	1,8	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	1,1	
Kya/Sill	7,9	
Staurolite	0,0	
Zircon	4,3	
Silicate	11,4	
Unclassified	2,9	
Total	100,0	

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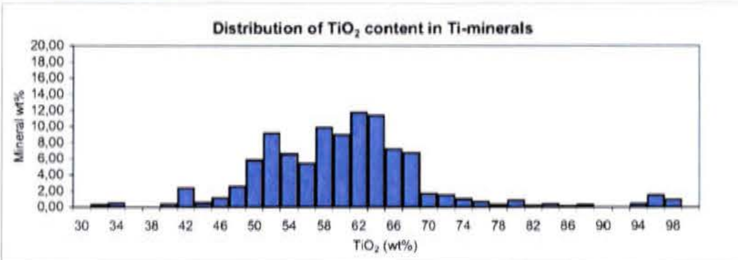
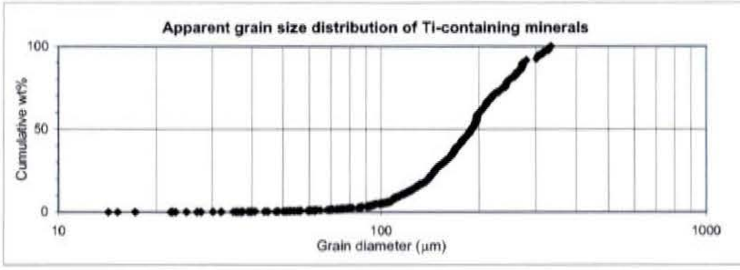
Lab. Name:	2000238	Analyzed by:	JK
Submitter:	H. stendal	Acc. Voltage	17kV
Date:	06-05-03		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm²)	Total grains
Ilmenite	1,6	1,9	635	248	19173	348
Leucoxene	1,7	1,7	544	201	15722	26
Rutile	1,6	1,6	444	160	12030	17
Ti magnetite	1,7	2,9	1015	457	30694	8
Magnetite	1,5	1,4	485	180	22554	8
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	1,3	1,4	410	140	9972	18
Y-phosphate	0,0	0,0	0	0	0	0
Sphene	0,0	0,0	0	0	0	0
Garnet	1,6	2,1	501	203	11703	12
Kya/Sill	1,6	2,1	753	306	24048	50
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,5	1,6	452	165	10924	42
Silicate	1,5	1,9	660	260	20832	102
Unclassified	1,6	2,8	850	382	23490	23

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GEUS

Sample Name:		No. of frames analysed	35
Lab. Name:	2000240	No. of particles analysed:	875
Date:	07-05-03	Heavy minerals in raw sand (%):	0,00
Submitter:	H. Stendal		
Country:		Comments:	
Analyzed by:	JK		
Acc. Voltage/Magnification: 17kV/4x			
Guard region:	250 µm		
Sieve:	100 µm²		

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	58,6	36,8	0,5	0,1	0,6	0,7	1,0	0,1	0,3	98,6
Leucoxene	73,4	18,7	0,3	0,3	1,8	2,1	0,8	0,1	0,3	97,8
Rutile	96,0	0,6	0,0	0,2	0,4	0,3	0,0	0,0	0,5	98,1
Ti magnetite	43,6	39,5	1,4	0,4	3,5	0,7	1,2	0,0	5,6	95,7
Magnetite	1,1	73,8	0,0	0,2	5,3	14,9	0,6	0,2	0,5	96,6
Chromite	0,8	25,8	0,0	35,2	0,4	23,3	12,7	0,2	0,2	98,7
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	3,4	0,6	0,0	0,0	2,2	0,4	0,1	2,9	5,4	15,1
Y-phosphate	0,0	0,0	0,0	0,0	7,0	1,4	0,0	2,4	6,2	17,0
Sphene	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Garnet	0,2	33,8	0,6	0,1	36,2	19,5	7,1	0,7	0,2	98,4
Kya/Sill	0,2	0,7	0,1	0,2	42,8	53,8	0,0	0,1	0,1	98,0
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,2	0,5	0,1	0,1	29,5	0,1	0,1	0,1	65,2	95,8
Silicate	0,3	2,2	0,1	0,3	56,0	37,5	1,1	0,1	0,1	97,6
Unclassified	13,1	8,5	0,5	2,4	10,7	3,4	0,6	1,2	21,6	62,0

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	74,2	8,2	2,9	1,6	5,1	6,1	1,9	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average	Category			
content	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	59,4	75,1	97,9	45,5
Fe_2O_3 wt%	37,3	19,1	0,6	41,2
MnO wt%	0,6	0,3	0,0	1,5
Cr_2O_3 wt%	0,1	0,3	0,2	0,4
SiO_2 wt%	0,6	1,8	0,4	3,6
Al_2O_3 wt%	0,7	2,1	0,3	0,7
MgO wt%	1,0	0,8	0,0	1,2
CaO wt%	0,1	0,1	0,0	0,0
ZrO_2 wt%	0,3	0,3	0,5	5,8
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	61,9
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	60,6
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
	Heavy mineral concentrate	Raw sand
Category	wt %	wt %
Ilmenite	66,6	
Leucoxene	7,3	
Rutile	2,6	
Ti magnetite	1,5	
Magnetite	0,1	
Chromite	0,2	
Pyrite	0,0	
Phosphate	0,0	
Monazite	2,3	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	4,6	
Kya/Sill	1,7	
Staurolite	0,0	
Zircon	5,5	
Silicate	3,6	
Unclassified	4,0	
Total	100,0	

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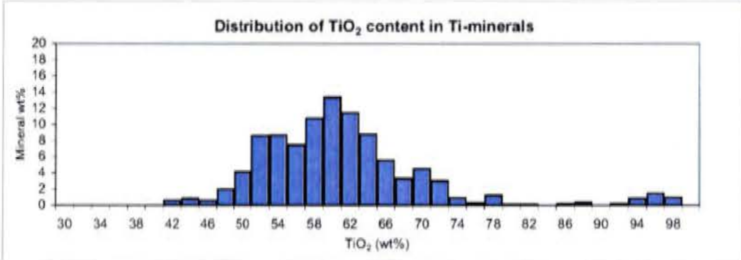
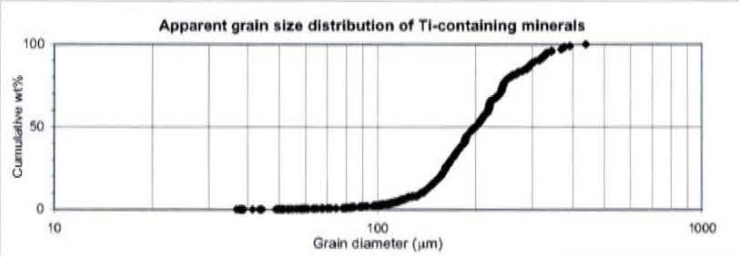
Lab. Name:	2000240	Analyzed by:	JK
Submitter:	H. Stendal	Acc. Voltage	17kV
Date:	07-05-03		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,6	1,8	675	255	22946	583
Leucoxene	1,5	1,8	798	307	30708	48
Rutile	1,6	1,8	671	259	20677	23
Ti magnetite	1,5	2,0	899	362	34652	8
Magnetite	1,5	1,9	546	215	12439	2
Chromite	1,1	1,4	753	250	31693	1
Pyrite	0,0	0,0	0	0	0	0
Phosphate	0,0	0,0	0	0	0	0
Monazite	1,5	1,5	490	169	14335	29
Y-phosphate	1,1	0,9	58	23	284	1
Sphene	0,0	0,0	0	0	0	0
Garnet	1,6	2,2	1032	419	45135	23
Kya/Sill	1,7	1,9	821	318	29338	16
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,4	1,5	536	191	17224	62
Silicate	1,6	2,1	966	396	37130	33
Unclassified	1,6	2,2	925	386	33234	40

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GEUS

Sample Name:	No. of frames analysed 81
Lab. Name: 2000668	No. of particles analysed: 646
Date:	Heavy minerals in raw
Submitter:	sand (%): 0,00
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	60,1	35,6	0,4	0,1	0,5	0,9	0,9	0,1	0,1	98,7
Leucoxene	74,7	18,9	0,3	0,3	0,8	1,9	0,6	0,1	0,3	98,0
Rutile	96,1	0,6	0,1	0,1	0,2	0,3	0,1	0,0	0,3	97,9
Ti magnetite	43,6	43,3	0,0	0,0	2,6	7,2	1,3	0,0	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	1,2	23,1	0,4	43,1	0,3	21,6	8,1	0,3	0,8	98,9
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	0,3	32,1	0,4	0,1	38,2	19,7	7,3	0,8	0,0	98,9
Kya/Sill	0,4	0,4	0,2	0,2	43,0	53,8	0,0	0,1	0,1	98,3
Staurolite	0,9	15,9	0,0	0,3	31,7	48,0	1,9	0,0	0,0	98,8
Zircon	0,3	0,3	0,1	0,1	27,1	0,1	0,1	0,1	61,5	89,6
Silicate	0,4	0,5	0,1	0,2	59,2	35,7	0,9	0,6	0,1	97,7
Unclassified	5,1	5,8	0,4	0,5	10,9	7,6	3,1	24,4	16,8	74,5

	Valuable heavy minerals								
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	81,0	6,8	3,6	0,0	3,0	4,1	1,0	0,6	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average	Category			
content	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	60,9	76,2	98,2	44,2
Fe_2O_3 wt%	36,1	19,3	0,6	44,0
MnO wt%	0,4	0,3	0,1	0,0
Cr_2O_3 wt%	0,1	0,3	0,1	0,0
SiO_2 wt%	0,5	0,9	0,2	2,7
Al_2O_3 wt%	0,9	2,0	0,4	7,3
MgO wt%	0,9	0,6	0,1	1,4
CaO wt%	0,1	0,1	0,0	0,0
ZrO_2 wt%	0,1	0,3	0,3	0,5
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	63,5
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	62,1
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
	Heavy mineral concentrate	Raw sand
Category	wt %	wt %
Ilmenite	76,5	
Leucoxene	6,4	
Rutie	3,4	
Ti magnetite	0,0	
Magnetite	0,0	
Chromite	0,1	
Pyrite	0,0	
Phosphate	0,0	
Morazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	2,8	
Kya/Sill	0,9	
Staurolite	0,6	
Zircon	3,9	
Silicate	4,6	
Unclassified	0,9	
Total	100,0	

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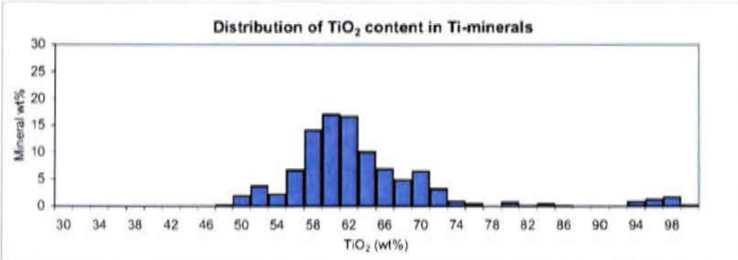
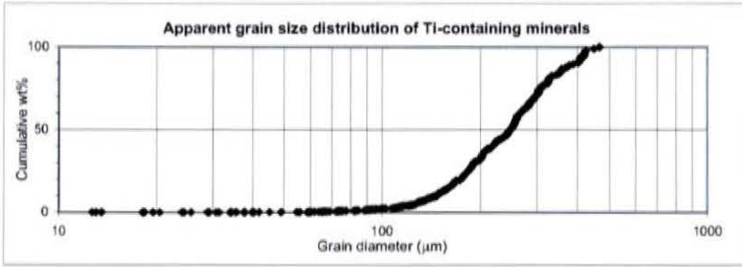
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,6	1,8	760	291	30446	472
Leucoxene	1,6	1,9	871	339	38731	31
Rutile	1,4	1,8	620	242	19807	29
Ti magnetite	1,3	1,2	83	25	451	1
Magnetite	0,0	0,0	0	0	0	0
Chromite	1,2	1,2	359	114	8657	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	1,9	2,2	1167	484	54660	11
Kya/Sill	2,3	3,3	1379	614	48619	5
Staurolite	1,4	1,8	1678	650	123105	1
Zircon	1,6	1,8	564	219	16317	43
Silicate	1,4	1,9	885	358	39738	37
Unclassified	1,7	2,1	595	252	18250	15

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GEUS

Sample Name:	No. of frames analysed: 81
Lab. Name: 2000672	No. of particles analysed: 656
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	59,4	36,4	0,5	0,1	0,4	0,7	0,9	0,1	0,1	98,8
Leucoxene	72,9	21,0	0,3	0,3	1,0	2,0	0,8	0,1	0,3	98,6
Rutile	94,8	1,0	0,2	0,1	0,5	0,4	0,1	0,1	0,2	97,4
Ti magnetite	43,4	29,5	2,5	0,0	0,0	5,7	0,0	0,0	0,0	81,1
Magnetite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Chromite	0,9	28,5	0,0	26,5	1,3	29,6	11,4	0,0	0,0	98,4
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	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Kya/Sill	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Staurolite	0,9	17,0	0,0	0,6	30,1	46,7	1,9	0,2	0,0	97,4
Zircon	0,3	0,3	0,1	0,2	27,1	0,0	0,1	0,1	61,3	89,5
Silicate	0,2	0,5	0,1	0,2	56,4	30,7	0,3	0,1	0,3	88,9
Unclassified	3,1	2,5	0,1	0,4	5,4	2,0	0,6	1,7	24,9	40,7

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	81,1	4,4	6,1	0,0	0,0	8,4	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%	60,2	73,9	97,3	53,5
Fe_2O_3 wt%	36,9	21,3	1,1	36,4
MnO wt%	0,5	0,3	0,2	3,1
Cr_2O_3 wt%	0,1	0,3	0,1	0,0
SiO_2 wt%	0,4	1,0	0,5	0,0
Al_2O_3 wt%	0,7	2,0	0,4	7,1
MgO wt%	0,9	0,8	0,1	0,0
CaO wt%	0,1	0,1	0,1	0,0
ZrO_2 wt%	0,1	0,3	0,2	0,0
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	63,3
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	60,9
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	76,7	
Leucoxene	4,2	
Rutile	5,8	
Ti magnetite	0,0	
Magnetite	0,0	
Chromite	0,1	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,0	
Kya/Sill	0,0	
Staurolite	0,0	
Zircon	7,9	
Silicate	3,5	
Unclassified	1,8	
Total	100,0	

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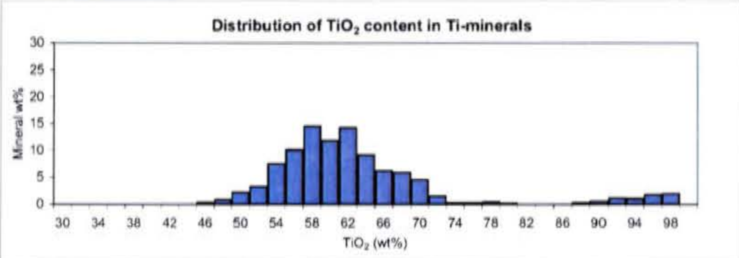
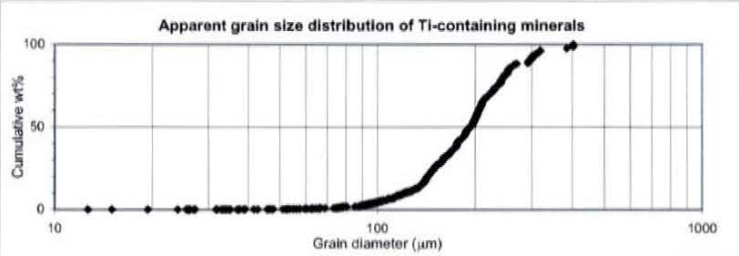
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm²)	Total grains
	Average grain parameters					
Ilmenite	1,5	1,7	626	234	21067	441
Leucoxene	1,5	1,7	535	199	16234	31
Rutile	1,6	1,7	547	202	15778	40
Ti magnetite	1,1	0,9	39	15	126	1
Magnetite	0,0	0,0	0	0	0	0
Chromite	1,3	1,4	513	167	14965	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	0,0	0,0	0	0	0	0
Kya/Sill	0,0	0,0	0	0	0	0
Staurolite	1,5	1,7	161	59	1243	1
Zircon	1,5	1,7	501	190	13640	68
Silicate	1,7	2,7	851	377	30937	23
Unclassified	1,5	1,6	375	142	9071	41

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GEUS

Sample Name:	No. of frames analysed 44
Lab. Name: 2000676	No. of particles analysed: 659
Date:	Heavy minerals in raw
Submitter:	sand (%): 0,00
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	61,2	34,4	0,4	0,1	0,5	0,9	0,9	0,1	0,2	98,7
Leucoxene	75,5	18,5	0,2	0,3	0,9	1,9	0,8	0,2	0,3	98,5
Rutile	93,6	1,9	0,1	0,1	1,1	0,9	0,2	0,1	0,4	98,4
Ti magnetite	36,8	45,0	0,2	0,0	5,8	10,9	0,0	0,0	0,1	98,9
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	0,5	30,6	1,2	0,1	38,4	19,4	6,8	0,9	0,4	98,3
Kya/Sill	0,3	0,6	0,1	0,2	42,8	53,7	0,1	0,1	0,2	97,9
Staurolite	0,4	17,7	0,0	0,2	31,0	47,8	1,5	0,2	0,0	98,8
Zircon	0,6	0,5	0,3	0,0	27,0	0,1	0,1	0,1	60,4	89,1
Silicate	0,5	2,4	0,1	0,3	47,9	46,5	0,3	0,1	0,1	98,3
Unclassified	1,3	7,5	0,2	0,5	2,6	49,1	15,1	14,0	5,1	95,3

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	83,5	7,8	2,8	0,2	3,4	0,4	1,7	0,2	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average	Category			
content	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	62,0	76,6	95,1	37,2
Fe_2O_3 wt%	34,9	18,8	2,0	45,6
MnO wt%	0,4	0,2	0,1	0,2
Cr_2O_3 wt%	0,1	0,3	0,1	0,0
SiO_2 wt%	0,5	0,9	1,2	5,8
Al_2O_3 wt%	0,9	1,9	1,0	11,1
MgO wt%	0,9	0,8	0,2	0,0
CaO wt%	0,1	0,2	0,1	0,0
ZrO_2 wt%	0,2	0,3	0,4	0,1
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	64,1
Average TiO_2 content of all the TiO_2 minerals excl. rutile.	63,2
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
	Heavy mineral concentrate	Raw sand
Category	wt %	wt %
Ilmenite	73,0	
Leucoxene	6,9	
Rutile	2,4	
Ti magnetite	0,1	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	3,0	
Kya/Sill	1,5	
Staurolite	0,2	
Zircon	0,4	
Silicate	11,3	
Unclassified	1,2	
Total	100,0	

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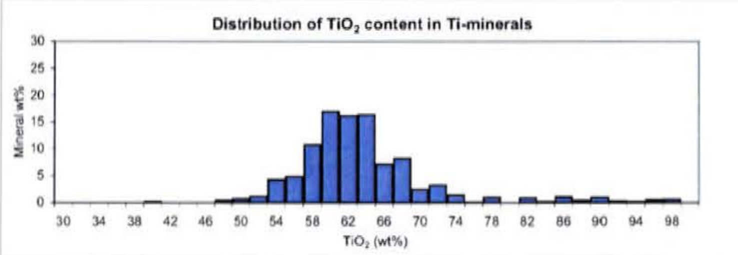
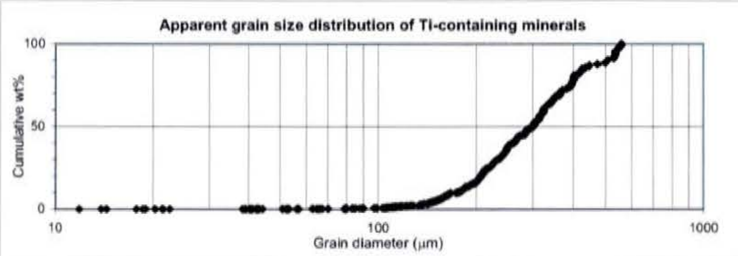
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm²)	Total grains
	Average grain parameters					
Ilmenite	1,5	1,7	879	324	44921	470
Leucoxene	1,7	1,7	876	332	42150	47
Rutile	1,5	1,7	973	365	45164	14
Ti magnetite	1,2	1,5	515	208	18445	2
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	1,6	2,0	959	385	51110	19
Kya/Sill	1,4	1,8	870	332	42740	14
Staurolite	1,5	1,5	1016	350	55398	1
Zircon	1,2	1,9	600	244	18357	6
Silicate	1,6	2,0	1244	503	75764	73
Unclassified	1,5	1,7	791	287	45641	13

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GEUS

Sample Name:	No. of frames analysed 64
Lab. Name: 2000677	No. of particles analysed: 819
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	60,4	35,4	0,5	0,1	0,4	0,8	0,9	0,1	0,2	98,8
Leucoxene	74,0	19,6	0,2	0,3	1,1	2,2	0,7	0,2	0,2	98,6
Rutile	94,5	1,3	0,1	0,1	0,7	0,8	0,1	0,1	0,2	98,0
Ti magnetite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
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	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Kya/Sill	0,4	0,3	0,3	0,2	42,6	54,0	0,0	0,0	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	0,1	0,2	27,0	0,0	0,1	0,1	61,3	89,3
Silicate	0,1	0,8	0,1	0,1	48,1	49,4	0,0	0,1	0,2	98,9
Unclassified	10,1	5,8	0,2	0,4	8,6	16,5	2,3	5,3	18,5	67,7

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	72,8	20,0	3,3	0,0	0,0	2,5	1,4	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average	Category			
content	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	61,1	75,1	96,5	0
Fe_2O_3 wt%	35,8	19,9	1,4	0
MnO wt%	0,5	0,2	0,1	0
Cr_2O_3 wt%	0,1	0,3	0,1	0
SiO_2 wt%	0,4	1,1	0,7	0
Al_2O_3 wt%	0,8	2,2	0,8	0
MgO wt%	0,9	0,7	0,1	0
CaO wt%	0,1	0,2	0,1	0
ZrO_2 wt%	0,2	0,2	0,2	0
Total	100,0	100,0	100,0	0

Average TiO_2 content of all the TiO_2 minerals:	65,2
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	64,1
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
	Heavy mineral concentrate	Raw sand
Category	wt %	wt %
Ilmenite	66,1	
Leucoxene	18,2	
Rutile	3,0	
Ti magnetite	0,0	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,0	
Kya/Sill	1,3	
Staurolite	0,0	
Zircon	2,3	
Silicate	8,1	
Unclassified	1,1	
Total	100,0	

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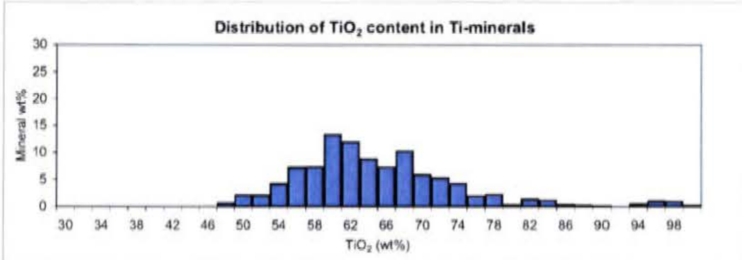
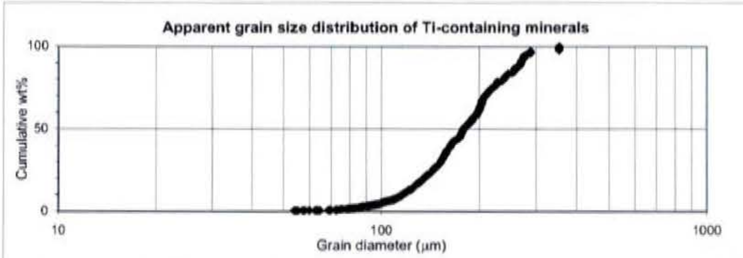
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm²)	Total grains
	Average grain parameters					
Ilmenite	1,6	1,8	590	224	17525	555
Leucoxene	1,5	1,7	671	255	23660	113
Rutile	1,6	1,8	534	205	15146	26
Ti magnetite	0,0	0,0	0	0	0	0
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	0,0	0,0	0	0	0	0
Kya/Sill	1,6	2,4	898	375	28357	9
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,5	1,6	397	143	8898	36
Silicate	1,6	2,0	885	355	36822	55
Unclassified	1,4	2,0	459	193	10814	25

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GEUS

Sample Name:		No. of frames analysed	34
Lab. Name: 2000679		No. of particles analysed:	635
Date:		Heavy minerals in raw sand (%):	0,00
Submitter:		Comments:	
Country:			
Analyzed by:			
Acc. Voltage/Magnification: 17kV/100x			
Guard region:	µm		
Sieve:	100 μm^2		

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	59,6	36,3	0,5	0,1	0,4	0,8	0,9	0,1	0,1	98,8
Leucoxene	74,4	18,9	0,3	0,2	0,9	2,4	0,5	0,2	0,4	98,3
Rutile	94,6	1,5	0,1	0,1	0,4	0,7	0,1	0,1	0,4	98,0
Ti magnetite	38,7	32,6	0,1	0,2	21,1	1,0	0,7	0,1	0,1	94,5
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	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Kya/Sill	0,2	0,4	0,1	0,2	43,1	54,1	0,0	0,1	0,2	98,4
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,4	0,3	0,2	0,1	27,0	0,1	0,1	0,1	61,0	89,2
Silicate	0,7	0,5	0,1	0,1	74,1	21,8	0,1	0,0	0,1	97,7
Unclassified	6,3	3,1	0,3	0,7	17,8	4,0	0,5	5,2	31,6	69,4

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	82,0	8,3	2,6	0,8	0,0	4,2	2,1	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	60,3	75,7	96,5	41,0
Fe_2O_3 wt%	36,7	19,3	1,6	34,5
MnO wt%	0,5	0,3	0,1	0,1
Cr_2O_3 wt%	0,1	0,2	0,1	0,2
SiO_2 wt%	0,4	0,9	0,4	22,3
Al_2O_3 wt%	0,8	2,5	0,7	1,0
MgO wt%	1,0	0,5	0,1	0,7
CaO wt%	0,1	0,2	0,1	0,1
ZrO_2 wt%	0,1	0,4	0,4	0,1
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	62,5
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	61,5
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	64,4	
Leucoxene	6,5	
Rutile	2,0	
Ti magnetite	0,6	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,0	
Kya/Sill	1,7	
Staurolite	0,0	
Zircon	3,3	
Silicate	20,0	
Unclassified	1,5	
Total	100,0	

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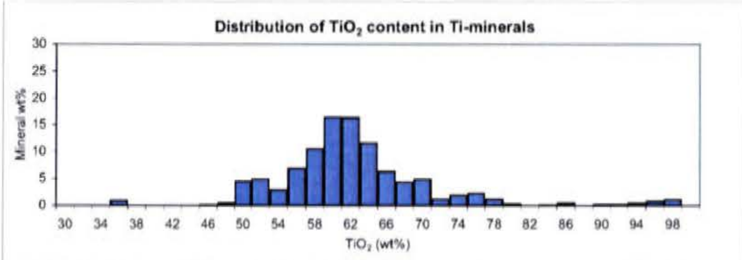
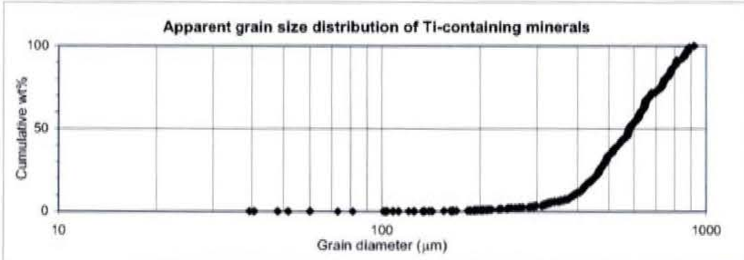
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm^2)	Total grains
Ilmenite	1,6	1,7	1892	702	191865	377
Leucoxene	1,5	1,7	2053	774	215123	34
Rutile	1,4	1,7	1905	693	185505	11
Ti magnetite	1,6	2,1	2605	1138	332100	2
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	0,0	0,0	0	0	0	0
Kya/Sill	1,7	2,0	2476	988	260323	10
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,4	1,6	1366	491	112666	32
Silicate	1,5	1,8	2173	851	264493	144
Unclassified	1,5	1,6	1282	499	111754	25

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GEUS

Sample Name:	No. of frames analysed 67
Lab. Name: 2000680	No. of particles analysed: 771
Date:	Heavy minerals in raw
Submitter:	sand (%): 0,00
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	59,0	36,6	0,5	0,1	0,7	1,0	0,8	0,1	0,2	98,9
Leucoxene	73,8	20,5	0,1	0,3	0,7	2,3	0,5	0,1	0,3	98,6
Rutile	96,5	0,7	0,1	0,1	0,3	0,3	0,1	0,0	0,4	98,4
Ti magnetite	43,7	33,9	0,2	0,1	5,3	1,0	1,2	0,2	8,1	93,7
Magnetite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Chromite	0,8	57,6	0,7	16,5	3,0	1,2	0,8	0,5	0,0	81,2
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	4,6	27,8	0,6	0,1	37,3	20,0	2,7	1,3	0,0	94,4
Kya/Sill	0,1	0,4	0,1	0,1	42,7	54,2	0,0	0,0	0,3	97,9
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,2	0,2	0,2	0,1	27,1	0,1	0,1	0,1	61,3	89,5
Silicate	1,4	1,7	0,1	0,2	49,4	43,4	0,3	0,5	0,1	97,1
Unclassified	2,8	2,7	0,2	0,4	7,0	8,2	0,7	1,4	21,2	44,7

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	77,8	4,5	6,0	0,4	0,0	10,5	0,7	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average	Category			
content	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	59,6	74,8	98,0	46,6
Fe_2O_3 wt%	37,0	20,8	0,7	36,2
MnO wt%	0,5	0,2	0,1	0,2
Cr_2O_3 wt%	0,1	0,3	0,1	0,1
SiO_2 wt%	0,7	0,7	0,3	5,7
Al_2O_3 wt%	1,0	2,3	0,3	1,1
MgO wt%	0,9	0,5	0,1	1,2
CaO wt%	0,1	0,1	0,0	0,2
ZrO_2 wt%	0,2	0,3	0,4	8,7
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	62,9
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	60,4
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
	Heavy mineral concentrate	Raw sand
Category	wt %	wt %
Ilmenite	74,9	
Leucoxene	4,3	
Rutile	5,8	
Ti magnetite	0,4	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,0	
Kya/Sill	0,7	
Staurolite	0,0	
Zircon	10,1	
Silicate	2,6	
Unclassified	1,2	
Total	100,0	

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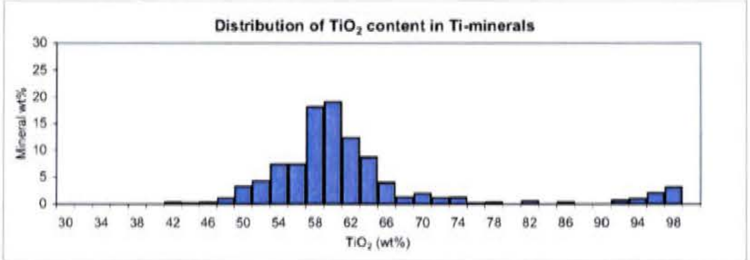
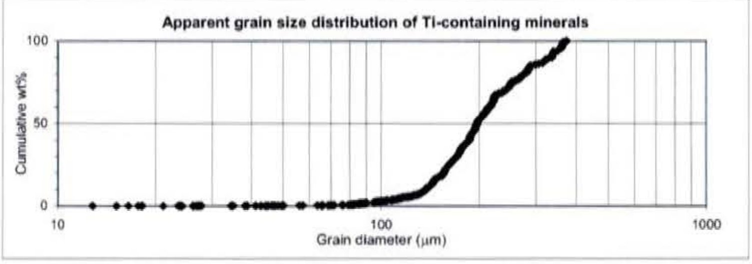
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,5	1,7	684	259	24367	530
Leucoxene	1,6	1,9	681	257	22523	33
Rutile	1,6	2,0	700	274	21978	41
Ti magnetite	1,6	2,3	579	244	12806	5
Magnetite	0,0	0,0	0	0	0	0
Chromite	1,3	1,4	75	23	330	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	1,2	101	39	834	3
Kya/Sill	1,3	1,6	929	341	43035	4
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,4	1,6	533	195	17183	98
Silicate	1,5	1,7	724	274	34516	22
Unclassified	1,4	1,7	422	161	9755	34

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GEUS

Sample Name:	No. of frames analysed: 64
Lab. Name: 2000681	No. of particles analysed: 675
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	58,7	35,5	0,4	0,1	1,4	1,7	0,8	0,1	0,1	98,9
Leucoxene	75,6	15,7	0,2	0,3	2,4	3,4	0,4	0,3	0,2	98,3
Rutile	94,2	1,0	0,2	0,0	1,1	1,0	0,1	0,1	0,3	98,1
Ti magnetite	44,9	50,1	1,2	0,0	1,0	0,7	0,9	0,2	0,0	98,9
Magnetite	1,9	64,1	0,6	0,4	11,9	6,4	0,4	4,7	2,8	93,3
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	2,4	19,9	0,7	0,3	43,1	21,7	0,8	1,7	2,8	93,4
Kya/Sill	0,3	0,8	0,2	0,2	42,8	53,7	0,1	0,1	0,3	98,5
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,2	0,5	0,2	0,1	27,2	0,4	0,1	0,1	60,7	89,4
Silicate	0,5	3,3	0,1	0,1	54,4	38,2	0,3	0,5	0,3	97,8
Unclassified	2,4	12,0	0,3	0,1	20,4	11,2	1,0	7,2	13,6	68,1

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	79,4	7,2	5,0	0,5	0,4	4,0	3,5	0,0	100,0

	Normalised average contents of the valuable Ti-containing minerals:			
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	59,3	76,9	96,1	45,3
Fe_2O_3 wt%	35,9	15,9	1,1	50,7
MnO wt%	0,4	0,2	0,2	1,2
Cr_2O_3 wt%	0,1	0,3	0,0	0,0
SiO_2 wt%	1,5	2,4	1,1	1,0
Al_2O_3 wt%	1,7	3,4	1,0	0,8
MgO wt%	0,8	0,4	0,1	0,9
CaO wt%	0,2	0,3	0,1	0,2
ZrO_2 wt%	0,1	0,2	0,3	0,0
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	62,6
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	60,7
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	64,6	
Leucoxene	5,8	
Rutile	4,1	
Ti magnetite	0,4	
Magnetite	0,1	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,3	
Kya/Sill	2,8	
Staurolite	0,0	
Zircon	3,3	
Silicate	16,9	
Unclassified	1,7	
Total	100,0	

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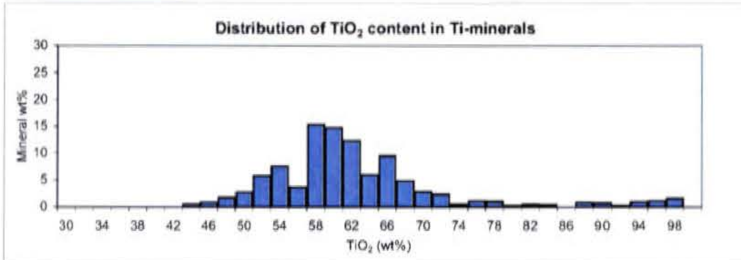
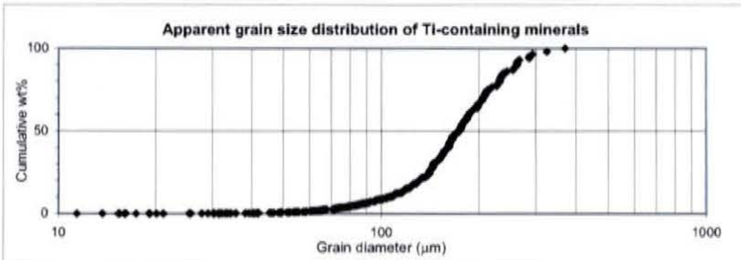
GEUS

Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,6	1,8	540	205	15965	294
Leucoxene	1,6	1,7	447	167	12096	35
Rutile	1,7	1,8	475	180	11663	23
Ti magnetite	1,7	1,7	447	168	9536	3
Magnetite	1,3	1,3	108	37	853	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	1,3	1,5	112	45	912	27
Kya/Sill	1,6	1,9	539	213	14919	19
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,6	1,8	454	174	10530	22
Silicate	1,6	1,9	398	160	9790	213
Unclassified	1,4	1,5	262	100	5795	35

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GEUS

Sample Name:	No. of frames analysed: 64
Lab. Name: 2000682	No. of particles analysed: 919
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 μm^2	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	58,6	35,8	0,5	0,1	1,3	1,5	0,8	0,1	0,1	98,9
Leucoxene	74,7	16,4	0,1	0,3	2,6	3,6	0,5	0,1	0,2	98,7
Rutile	91,8	1,7	0,2	0,2	1,9	2,0	0,1	0,1	0,3	98,3
Ti magnetite	38,9	32,3	0,9	0,1	12,6	12,9	0,7	0,1	0,2	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	2,0	18,4	0,5	1,0	43,8	20,5	2,5	2,7	1,4	92,8
Kya/Sill	0,3	0,5	0,1	0,2	42,8	54,0	0,0	0,1	0,2	98,3
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	0,1	0,1	27,1	0,2	0,1	0,1	61,1	89,2
Silicate	0,6	2,0	0,2	0,2	52,5	41,1	0,5	0,7	0,2	97,9
Unclassified	2,5	3,1	0,2	0,3	17,2	8,3	0,8	1,5	19,2	53,1

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	70,2	9,0	9,7	1,7	0,1	5,4	4,0	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average	Category			
content	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	59,2	75,7	93,4	39,5
Fe_2O_3 wt%	36,2	16,7	1,8	32,7
MnO wt%	0,5	0,1	0,2	0,9
Cr_2O_3 wt%	0,1	0,3	0,2	0,1
SiO_2 wt%	1,3	2,6	1,9	12,8
Al_2O_3 wt%	1,6	3,7	2,0	13,1
MgO wt%	0,8	0,5	0,1	0,7
CaO wt%	0,1	0,1	0,1	0,1
ZrO_2 wt%	0,1	0,2	0,3	0,2
Total	100,0	100,0	100,0	100,0

Weight percent on a mineral basis:		
	Heavy mineral concentrate	Raw sand
Category	wt %	wt %
Ilmenite	56,2	
Leucoxene	7,2	
Rutile	7,7	
Ti magnetite	1,4	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,1	
Kya/Sill	3,2	
Staurolite	0,0	
Zircon	4,3	
Silicate	18,2	
Unclassified	1,7	
Total	100,0	

Average TiO_2 content of all the TiO_2 minerals:	64,2
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	60,7
Valuable heavy minerals in raw sand:	0,00

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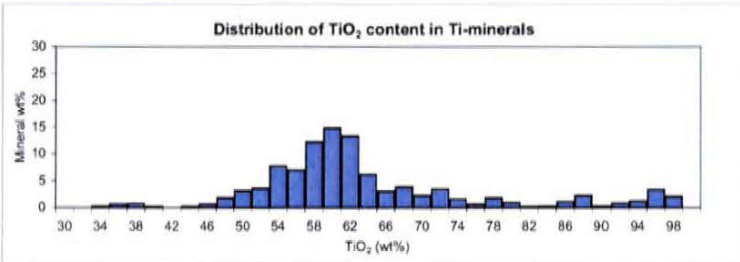
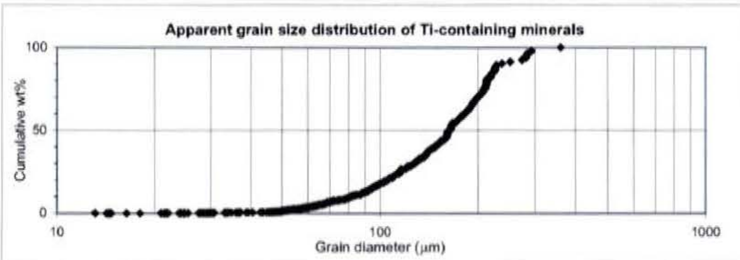
GEUS

Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
	Average grain parameters					
Ilmenite	1,5	1,7	445	166	11837	313
Leucoxene	1,7	1,7	360	137	7302	65
Rutile	1,7	1,6	401	148	10419	44
Ti magnetite	1,5	2,4	545	235	10474	8
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	1,5	105	39	661	10
Kya/Sill	1,7	2,0	360	142	6512	45
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,4	1,6	321	114	6522	42
Silicate	1,6	1,8	313	124	5671	359
Unclassified	1,6	1,7	296	117	5535	33

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GEUS

Sample Name:	No. of frames analysed: 64
Lab. Name: 2000683	No. of particles analysed: 2311
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 μm^2	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	58,5	36,2	0,5	0,1	1,1	1,3	0,8	0,1	0,1	98,8
Leucoxene	75,0	16,2	0,3	0,2	2,7	3,2	0,5	0,2	0,3	98,6
Rutile	94,3	1,4	0,1	0,2	1,0	1,2	0,1	0,1	0,2	98,5
Ti magnetite	37,8	33,2	0,2	0,1	16,2	9,1	1,5	0,1	0,1	98,4
Magnetite	0,7	78,7	0,2	0,1	7,8	7,4	0,7	0,4	1,5	97,4
Chromite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Pyrite	0,0	33,8	0,1	0,0	0,4	0,2	0,0	0,0	0,4	35,0
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	2,3	24,4	0,5	0,2	38,5	20,7	3,9	7,6	0,2	98,4
Kya/Sill	0,3	0,7	0,2	0,2	42,7	54,1	0,0	0,1	0,2	98,4
Staurolite	5,2	10,8	0,1	0,2	32,5	44,7	4,9	0,0	0,3	98,8
Zircon	0,3	0,3	0,1	0,1	27,0	0,3	0,1	0,1	61,1	89,3
Silicate	0,7	1,3	0,1	0,1	61,4	32,9	0,4	0,6	0,1	97,7
Unclassified	7,1	5,8	0,2	0,3	20,0	13,8	0,7	1,5	18,7	68,2

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	70,4	13,4	6,3	1,6	1,5	4,7	2,1	0,1	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	59,2	76,1	95,7	38,4
Fe_2O_3 wt%	36,6	16,4	1,4	33,8
MnO wt%	0,5	0,3	0,1	0,2
Cr_2O_3 wt%	0,1	0,2	0,2	0,1
SiO_2 wt%	1,2	2,8	1,0	16,4
Al_2O_3 wt%	1,4	3,2	1,2	9,3
MgO wt%	0,8	0,5	0,1	1,5
CaO wt%	0,1	0,2	0,1	0,1
ZrO_2 wt%	0,1	0,3	0,2	0,1
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	63,8
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	61,5
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	57,2	
Leucoxene	10,9	
Rutile	5,1	
Ti magnetite	1,3	
Magnetite	0,2	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	1,3	
Kya/Sill	1,7	
Staurolite	0,0	
Zircon	3,8	
Silicate	15,7	
Unclassified	2,8	
Total	100,0	

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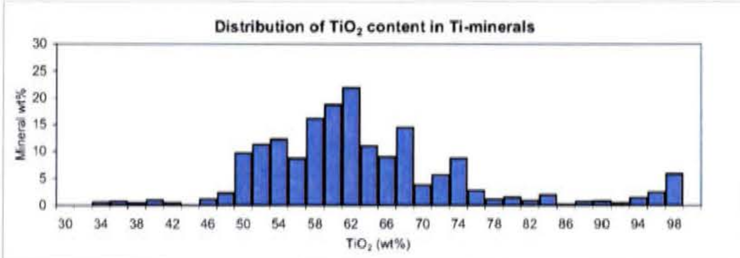
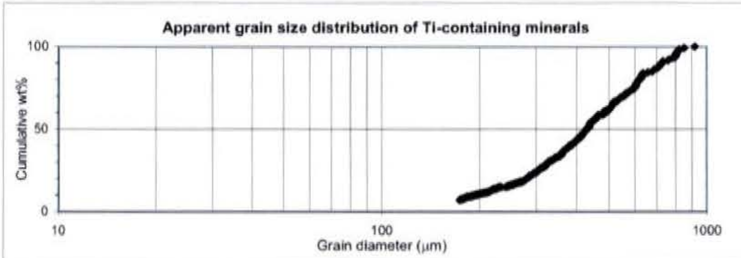
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm²)	Total grains
Ilmenite	1,6	1,8	1123	433	73034	791
Leucoxene	1,6	1,7	939	358	57051	191
Rutile	1,6	1,7	986	369	57780	82
Ti magnetite	1,5	2,7	1540	672	77598	15
Magnetite	1,4	1,8	783	307	29795	5
Chromite	0,0	0,0	0	0	0	0
Pyrite	1,1	1,4	495	155	14284	3
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	1,8	1,9	963	401	70432	20
Kya/Sill	1,8	2,0	890	354	37373	57
Staurolite	1,3	1,5	509	182	14809	3
Zircon	1,5	1,7	996	376	57743	62
Silicate	1,7	1,9	866	343	41548	656
Unclassified	1,6	2,0	943	394	45899	98

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GEUS

Sample Name:	No. of frames analysed: 39
Lab. Name: 2000692	No. of particles analysed: 633
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 μm^2	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	59,7	36,1	0,5	0,1	0,4	0,7	0,9	0,1	0,2	98,7
Leucoxene	74,3	20,5	0,3	0,1	0,6	1,8	0,6	0,1	0,3	98,6
Rutile	95,6	0,6	0,2	0,1	0,3	0,3	0,1	0,1	0,4	97,6
Ti magnetite	42,9	42,6	0,6	0,2	0,3	11,4	0,7	0,1	0,2	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	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Kya/Sill	0,2	0,5	0,2	0,3	43,0	53,9	0,0	0,1	0,1	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	0,2	0,2	0,1	27,1	0,1	0,1	0,1	61,6	89,6
Silicate	0,3	0,8	0,1	0,2	62,9	32,1	0,2	0,7	0,3	97,6
Unclassified	3,3	1,9	0,5	0,7	9,0	1,9	1,0	10,3	31,2	59,8

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	81,5	4,7	5,5	0,5	0,0	6,8	1,0	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	60,5	75,3	97,9	43,4
Fe_2O_3 wt%	36,6	20,8	0,6	43,0
MnO wt%	0,5	0,3	0,2	0,6
Cr_2O_3 wt%	0,1	0,1	0,1	0,2
SiO_2 wt%	0,4	0,6	0,3	0,3
Al_2O_3 wt%	0,7	1,8	0,3	11,5
MgO wt%	0,9	0,7	0,1	0,7
CaO wt%	0,1	0,1	0,1	0,1
ZrO_2 wt%	0,2	0,3	0,4	0,2
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	63,4
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	77,7	
Leucoxene	4,5	
Rutile	5,3	
Ti magnetite	0,5	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,0	
Kya/Sill	1,0	
Staurolite	0,0	
Zircon	6,5	
Silicate	3,4	
Unclassified	1,2	
Total	100,0	

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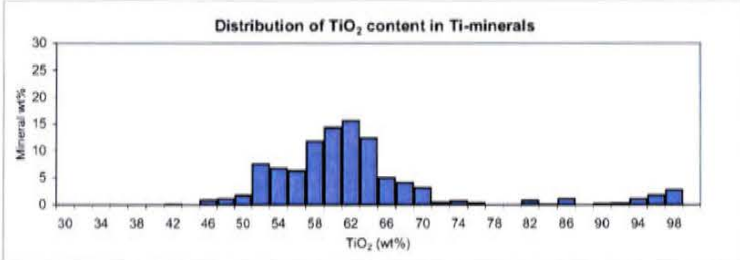
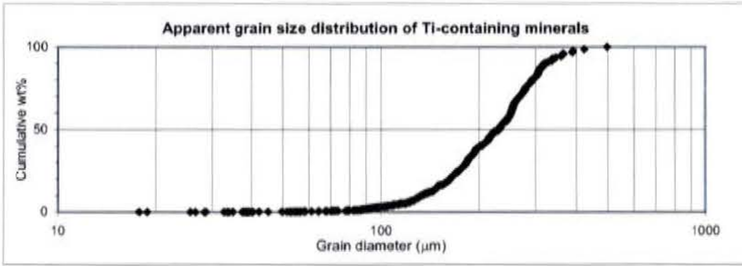
GEUS

Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	
Ilmenite	1,5	1,8	719	274	26447	457
Leucoxene	1,4	1,6	691	252	27980	25
Rutile	1,6	1,7	674	251	26368	28
Ti magnetite	1,6	2,0	702	296	23226	3
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	0,0	0,0	0	0	0	0
Kya/Sill	1,9	2,5	834	346	25603	8
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,4	1,7	581	217	18351	53
Silicate	1,6	2,2	878	364	32064	28
Unclassified	1,5	1,5	370	145	10001	31

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GEUS

Sample Name:	No. of frames analysed: 64
Lab. Name: 2000693	No. of particles analysed: 980
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	60,2	35,3	0,5	0,1	0,7	0,9	0,9	0,1	0,2	98,8
Leucoxene	74,8	18,2	0,3	0,3	1,5	2,4	0,6	0,1	0,3	98,6
Rutile	95,4	0,9	0,1	0,3	0,4	0,5	0,1	0,1	0,3	98,1
Ti magnetite	38,1	33,4	0,3	0,2	16,7	9,0	1,0	0,1	0,2	98,9
Magnetite	4,0	71,9	0,6	0,0	5,6	2,2	3,1	1,5	3,7	92,6
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	0,8	32,3	0,2	0,2	38,5	19,7	6,7	0,9	0,0	99,3
Kya/Sill	0,2	0,5	0,2	0,2	42,7	54,2	0,1	0,1	0,2	98,5
Staurolite	9,6	8,0	0,3	0,2	31,4	46,8	0,2	0,0	1,1	97,8
Zircon	0,2	0,3	0,1	0,1	27,2	0,1	0,1	0,0	61,5	89,6
Silicate	0,9	0,6	0,1	0,1	70,0	26,1	0,2	0,2	0,1	98,4
Unclassified	8,0	5,4	0,4	0,1	13,0	11,4	2,0	8,3	15,1	63,7

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	79,8	8,0	5,5	1,6	0,2	3,1	1,7	0,1	100,0

	Normalised average contents of the valuable Ti-containing minerals:			
Average	Category			
content	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	60,9	75,9	97,3	38,5
Fe_2O_3 wt%	35,8	18,5	0,9	33,8
MnO wt%	0,5	0,3	0,1	0,3
Cr_2O_3 wt%	0,1	0,3	0,3	0,2
SiO_2 wt%	0,7	1,6	0,4	16,9
Al_2O_3 wt%	0,9	2,5	0,5	9,1
MgO wt%	0,9	0,6	0,1	1,0
CaO wt%	0,1	0,2	0,1	0,1
ZrO_2 wt%	0,2	0,3	0,3	0,2
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	63,9
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	61,8
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
	Heavy mineral concentrate	Raw sand
Category	wt %	wt %
Ilmenite	63,9	
Leucoxene	6,4	
Rutile	4,4	
Ti magnetite	1,2	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,2	
Kya/Sill	1,3	
Staurolite	0,1	
Zircon	2,5	
Silicate	17,4	
Unclassified	2,5	
Total	100,0	

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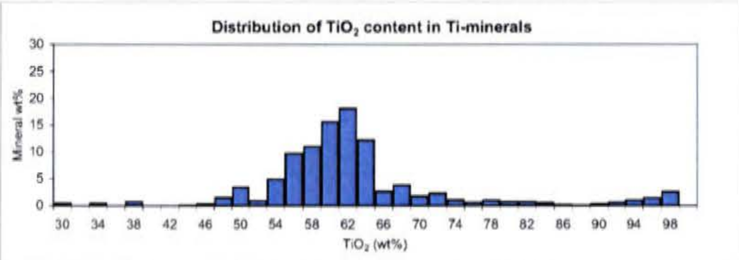
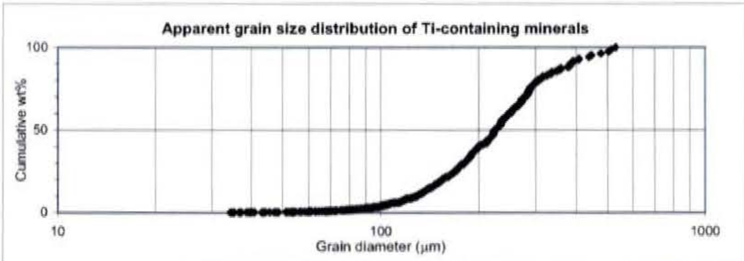
GEUS

Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm^2)	Total grains
Ilmenite	1,6	2,0	735	293	25314	547
Leucoxene	1,6	1,7	582	222	18745	74
Rutile	1,6	1,8	546	211	16986	51
Ti magnetite	1,8	2,8	1135	503	42209	6
Magnetite	1,5	1,2	87	28	516	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	0,0	0,0	0	0	0	0
Garnet	1,9	1,9	367	146	7196	6
Kya/Sill	1,6	2,1	784	322	26637	15
Staurolite	2,1	3,5	981	440	22050	1
Zircon	1,6	1,8	488	184	12809	41
Silicate	1,6	2,2	863	356	33093	193
Unclassified	1,6	1,9	623	254	20073	45

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GEUS

Sample Name:	No. of frames analysed: 64
Lab. Name: 2000694	No. of particles analysed: 990
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	Comments:
Country:	
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	60,0	35,8	0,4	0,1	0,5	0,8	0,9	0,1	0,2	98,9
Leucoxene	73,7	18,2	0,2	0,2	2,2	2,9	0,7	0,2	0,4	98,7
Rutile	95,6	1,0	0,1	0,2	0,3	0,4	0,1	0,1	0,2	98,0
Ti magnetite	42,5	28,4	1,0	0,5	7,1	3,3	1,9	0,1	7,4	92,2
Magnetite	1,0	53,6	0,0	0,0	21,6	22,3	0,0	0,2	0,0	98,9
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	0,1	31,8	0,9	0,1	38,0	19,9	7,5	0,9	0,0	99,2
Kya/Sill	0,3	0,4	0,0	0,3	42,7	53,9	0,1	0,1	0,0	97,8
Staurolite	1,1	14,3	0,0	0,0	31,4	48,4	2,9	0,0	0,0	98,1
Zircon	0,2	0,3	0,1	0,1	27,2	0,1	0,1	0,1	61,8	89,9
Silicate	0,7	0,6	0,1	0,1	75,1	20,5	0,4	0,1	0,1	97,7
Unclassified	1,9	9,3	0,2	0,7	7,9	10,8	1,9	9,5	16,3	58,4

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	79,5	7,6	4,0	0,3	4,3	3,9	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%	60,7	74,7	97,6	46,1
Fe_2O_3 wt%	36,3	18,5	1,0	30,8
MnO wt%	0,4	0,2	0,1	1,1
Cr_2O_3 wt%	0,1	0,2	0,2	0,5
SiO_2 wt%	0,5	2,3	0,3	7,7
Al_2O_3 wt%	0,8	2,9	0,4	3,6
MgO wt%	0,9	0,7	0,1	2,1
CaO wt%	0,1	0,2	0,1	0,1
ZrO_2 wt%	0,2	0,4	0,2	8,1
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	63,4
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	61,8
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	73,0	
Leucoxene	7,0	
Rutile	3,7	
Ti magnetite	0,3	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	3,9	
Kya/Sill	0,4	
Staurolite	0,0	
Zircon	3,6	
Silicate	6,9	
Unclassified	1,2	
Total	100,0	

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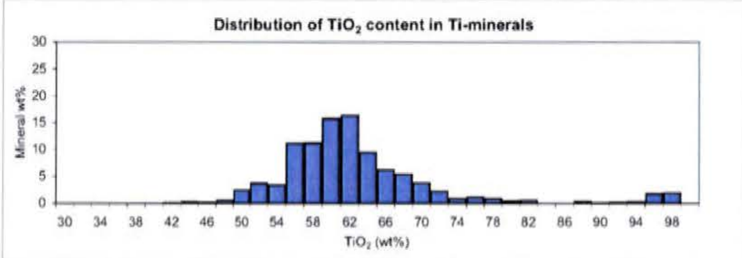
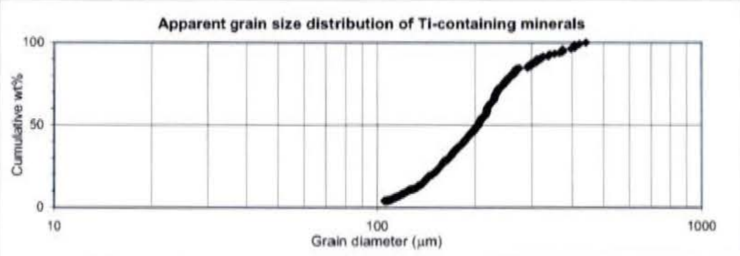
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
	Average grain parameters					
Ilmenite	1,6	1,7	646	238	23135	689
Leucoxene	1,4	1,7	631	235	22133	69
Rutile	1,5	1,6	541	200	16864	43
Ti magnetite	1,7	1,9	420	171	9486	6
Magnetite	1,3	2,4	375	158	4603	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	0,0	0,0	0	0	0	0
Garnet	1,5	2,0	1506	606	106659	9
Kya/Sill	1,9	2,2	1028	419	41309	3
Staurolite	1,6	1,7	200	76	1834	1
Zircon	1,5	1,7	475	173	12306	61
Silicate	1,5	1,9	866	351	36248	71
Unclassified	1,8	1,9	469	189	11784	37

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GEUS

Sample Name:	No. of frames analysed: 39
Lab. Name: 2000695	No. of particles analysed: 611
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	60,8	34,3	0,4	0,1	0,8	1,2	0,9	0,1	0,1	98,9
Leucoxene	74,7	16,5	0,2	0,4	2,3	3,5	0,6	0,2	0,2	98,7
Rutile	91,3	2,3	0,1	0,8	0,9	2,3	0,1	0,2	0,3	98,3
Ti magnetite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Magnetite	0,8	58,6	0,2	0,2	10,2	19,5	0,3	0,0	1,1	90,9
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	1,2	32,9	0,6	0,1	34,4	18,4	2,4	2,4	1,4	93,7
Kya/Sill	0,2	0,5	0,1	0,2	42,4	54,5	0,0	0,1	0,2	98,3
Staurolite	1,1	17,6	0,0	0,0	31,1	46,8	2,1	0,0	0,0	98,7
Zircon	0,2	0,3	0,1	0,1	27,1	0,2	0,1	0,0	61,6	89,9
Silicate	0,3	1,3	0,1	0,2	49,5	46,5	0,3	0,2	0,1	98,6
Unclassified	2,5	12,0	1,1	1,1	4,5	23,3	4,8	32,8	4,8	87,1

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	71,0	15,2	4,2	0,0	0,3	3,6	5,6	0,2	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	61,5	75,7	92,9	0
Fe_2O_3 wt%	34,7	16,8	2,3	0
MnO wt%	0,4	0,2	0,1	0
Cr_2O_3 wt%	0,1	0,4	0,8	0
SiO_2 wt%	0,8	2,4	0,9	0
Al_2O_3 wt%	1,3	3,5	2,3	0
MgO wt%	0,9	0,6	0,1	0
CaO wt%	0,1	0,2	0,2	0
ZrO_2 wt%	0,1	0,2	0,3	0
Total	100,0	100,0	100,0	0

Average TiO_2 content of all the TiO_2 minerals:	65,4
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	64,0
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	54,7	
Leucoxene	11,8	
Rutile	3,2	
Ti magnetite	0,0	
Magnetite	0,8	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,2	
Kya/Sill	4,3	
Staurolite	0,1	
Zircon	2,8	
Silicate	19,6	
Unclassified	2,5	
Total	100,0	

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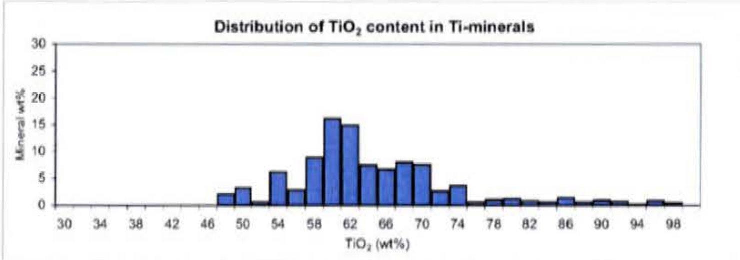
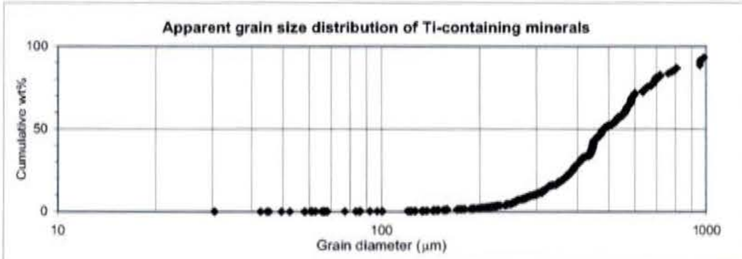
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm^2)	Total grains
Ilmenite	1,6	1,7	1483	561	124942	293
Leucoxene	1,5	1,7	1512	568	142987	55
Rutile	1,5	1,6	1376	505	102014	19
Ti magnetite	0,0	0,0	0	0	0	0
Magnetite	1,7	1,5	1044	378	114658	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	1,8	1,8	983	415	53921	3
Kya/Sill	1,7	2,1	1638	671	137654	29
Staurolite	2,0	2,7	1958	844	113979	1
Zircon	1,6	1,6	1244	454	99000	18
Silicate	1,6	2,0	1575	633	128750	173
Unclassified	2,0	1,8	1689	669	174854	16

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GEUS

Sample Name:		No. of frames analysed	30
Lab. Name: 2000696		No. of particles analysed:	610
Date:		Heavy minerals in raw sand (%):	0,00
Submitter:		Comments:	
Country:			
Analyzed by:			
Acc. Voltage/Magnification: 17kV/100x			
Guard region:	µm		
Sieve:	100 µm²		

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	60,2	34,4	0,4	0,1	1,2	1,6	0,8	0,1	0,2	98,9
Leucoxene	75,4	17,4	0,2	0,3	1,7	2,8	0,4	0,3	0,3	98,7
Rutile	92,4	1,9	0,2	0,1	1,9	1,7	0,1	0,2	0,2	98,6
Ti magnetite	36,1	38,1	0,6	0,0	12,8	9,4	1,8	0,0	0,2	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	0,8	16,8	1,8	0,7	39,9	19,2	3,8	0,4	7,1	90,5
Kya/Sill	0,2	0,6	0,1	0,2	42,7	54,1	0,1	0,1	0,1	98,3
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,1	0,3	0,2	0,1	27,2	0,2	0,1	0,1	60,9	89,3
Silicate	0,6	1,7	0,1	0,1	75,6	17,5	0,8	0,5	0,1	96,9
Unclassified	7,6	7,6	1,6	1,1	13,8	15,4	3,9	0,4	19,3	70,7

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	70,7	19,1	5,6	1,2	0,2	1,8	1,4	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	60,8	76,4	93,7	36,5
Fe_2O_3 wt%	34,8	17,6	2,0	38,5
MnO wt%	0,4	0,2	0,2	0,6
Cr_2O_3 wt%	0,1	0,3	0,1	0,0
SiO_2 wt%	1,2	1,7	1,9	13,0
Al_2O_3 wt%	1,6	2,8	1,7	9,5
MgO wt%	0,8	0,4	0,1	1,9
CaO wt%	0,1	0,3	0,2	0,0
ZrO_2 wt%	0,2	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:	65,5
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	63,8
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	51,4	
Leucoxene	13,9	
Rutile	4,1	
Ti magnetite	0,9	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,1	
Kya/Sill	1,0	
Staurolite	0,0	
Zircon	1,3	
Silicate	25,4	
Unclassified	1,8	
Total	100,0	

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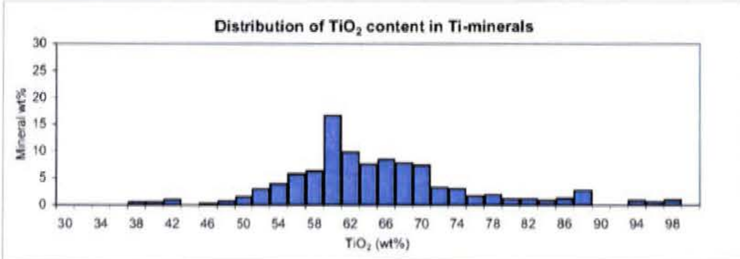
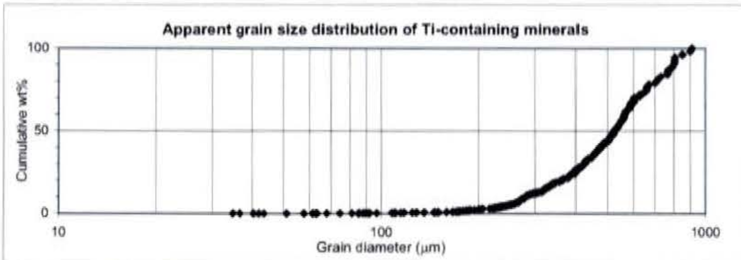
GEUS

Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,6	1,8	1501	570	124795	197
Leucoxene	1,5	1,8	1583	590	144137	46
Rutile	1,5	1,6	1225	441	97310	18
Ti magnetite	1,6	2,3	1604	672	97719	4
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	1,3	1,6	456	182	13248	6
Kya/Sill	1,7	2,2	1367	553	113677	6
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,5	1,7	824	302	37882	16
Silicate	1,7	1,9	1120	445	70414	293
Unclassified	1,6	1,5	990	408	91358	16

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GEUS

Sample Name:	No. of frames analysed 84
Lab. Name: 2000706	No. of particles analysed: 698
Date:	Heavy minerals in raw
Submitter:	sand (%): 0,00
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	58,8	35,9	0,6	0,2	0,6	0,9	0,9	0,1	0,3	98,3
Leucoxene	76,7	16,5	0,2	0,3	1,3	2,3	0,5	0,2	0,2	98,1
Rutile	94,5	1,1	0,2	0,2	0,4	0,5	0,1	0,0	0,4	97,3
Ti magnetite	40,8	28,7	3,1	0,2	1,2	9,9	0,5	0,3	3,5	88,3
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	0,2	31,3	0,1	0,3	38,1	19,8	7,8	0,7	0,0	98,4
Kya/Sill	0,4	0,5	0,1	0,4	42,6	53,6	0,0	0,2	0,1	97,9
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,2	0,3	0,1	0,1	27,3	0,2	0,1	0,1	61,7	90,0
Silicate	0,2	1,0	0,1	0,2	52,9	43,5	0,1	0,1	0,1	98,3
Unclassified	3,7	4,4	0,9	0,5	7,3	16,8	1,6	1,0	22,8	59,0

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	70,6	5,1	6,5	0,0	0,1	17,3	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%	59,8	78,1	97,0	46,2
Fe_2O_3 wt%	36,6	16,8	1,1	32,5
MnO wt%	0,6	0,2	0,2	3,5
Cr_2O_3 wt%	0,2	0,4	0,2	0,2
SiO_2 wt%	0,6	1,3	0,4	1,3
Al_2O_3 wt%	0,9	2,3	0,5	11,2
MgO wt%	0,9	0,5	0,1	0,6
CaO wt%	0,1	0,2	0,0	0,3
ZrO_2 wt%	0,3	0,2	0,4	4,0
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	63,9
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	61,1
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	67,2	
Leucoxene	4,9	
Rutile	6,2	
Ti magnetite	0,0	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,1	
Kya/Sill	0,4	
Staurolite	0,0	
Zircon	16,5	
Silicate	2,2	
Unclassified	2,5	
Total	100,0	

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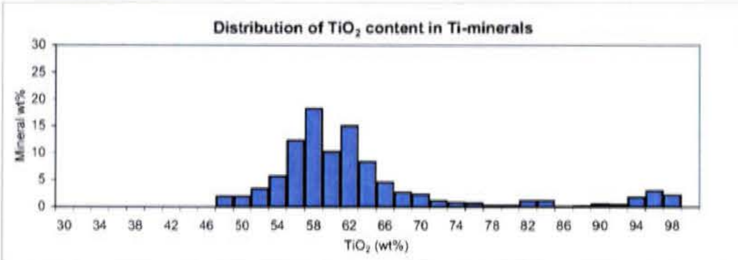
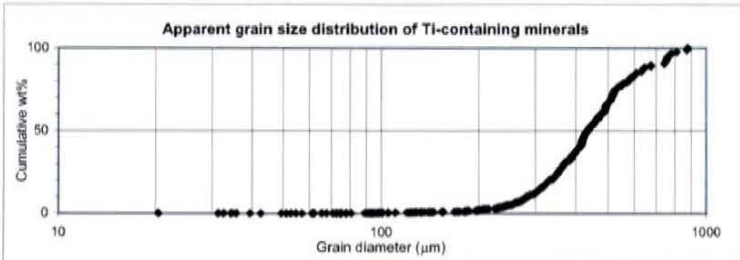
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,6	1,7	1424	532	109641	406
Leucoxene	1,6	1,9	1457	561	101122	32
Rutile	1,5	1,7	1274	484	94361	39
Ti magnetite	1,2	1,0	110	42	965	2
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	2,3	2,9	1015	447	32793	2
Kya/Sill	1,7	2,0	1708	673	130896	3
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,5	1,7	1260	470	84401	125
Silicate	1,5	1,8	1407	549	105078	24
Unclassified	1,6	1,6	799	317	47107	58

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GEUS

Sample Name:	No. of frames analysed 42
Lab. Name: 2000707	No. of particles analysed: 673
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	Comments:
Country:	
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

Category	Average content TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	59,5	34,3	0,5	0,2	1,3	1,8	0,9	0,1	0,1	98,7
Leucoxene	76,4	13,9	0,2	0,3	2,9	4,2	0,4	0,2	0,2	98,7
Rutile	93,8	1,5	0,1	0,1	1,0	1,3	0,1	0,1	0,2	98,2
Ti magnetite	40,7	37,6	0,5	0,0	8,0	10,2	0,8	0,0	0,5	98,2
Magnetite	1,5	69,3	0,2	0,9	4,4	1,4	0,0	0,0	13,8	91,6
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	0,5	12,4	0,6	0,1	42,8	12,9	4,5	23,8	0,6	98,2
Kya/Sill	0,3	0,5	0,2	0,2	42,4	54,4	0,1	0,1	0,3	98,3
Staurolite	0,8	7,7	0,0	0,0	45,3	41,8	0,1	0,0	1,5	97,2
Zircon	0,2	0,2	0,1	0,1	27,4	0,2	0,1	0,1	61,6	90,0
Silicate	0,3	1,1	0,1	0,2	48,8	47,0	0,6	0,2	0,2	98,5
Unclassified	2,2	3,5	0,1	0,5	10,1	14,7	4,3	1,2	15,8	52,3

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	72,1	16,2	5,7	0,1	0,0	3,1	2,8	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals

Average content	Category: Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	60,3	77,5	95,5	41,5
Fe_2O_3 wt%	34,8	14,1	1,5	38,3
MnO wt%	0,5	0,2	0,1	0,5
Cr_2O_3 wt%	0,2	0,3	0,1	0,0
SiO_2 wt%	1,3	2,9	1,0	8,2
Al_2O_3 wt%	1,8	4,2	1,3	10,4
MgO wt%	0,9	0,4	0,1	0,8
CaO wt%	0,1	0,2	0,1	0,0
ZrO_2 wt%	0,1	0,2	0,2	0,5
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	65,4
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	63,4
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:

Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	61,2	
Leucoxene	13,7	
Rutile	4,8	
Ti magnetite	0,1	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,0	
Kya/Sill	2,4	
Staurolite	0,0	
Zircon	2,7	
Silicate	14,1	
Unclassified	1,1	
Total	100,0	

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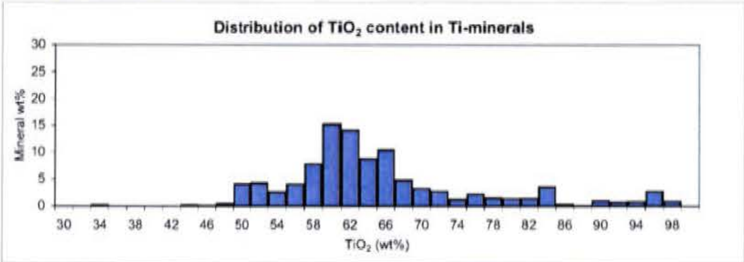
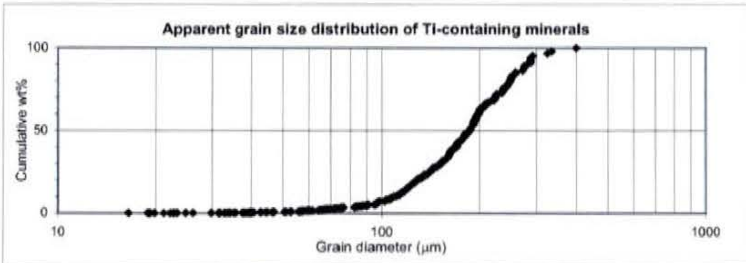
GEUS

Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm^2)	
Ilmenite	1,6	1,8	559	213	16767	286
Leucoxene	1,6	1,7	504	189	16309	66
Rutile	1,7	1,7	515	190	14806	23
Ti magnetite	1,3	1,5	187	76	2325	3
Magnetite	1,3	1,1	62	22	281	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	0,0	0,0	0	0	0	0
Garnet	1,7	1,5	133	46	985	2
Kya/Sill	1,6	1,8	295	119	5622	46
Staurolite	1,5	1,1	47	16	157	1
Zircon	1,4	1,6	396	140	9577	21
Silicate	1,6	2,0	405	168	9180	204
Unclassified	1,7	1,8	357	139	6891	20

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GEUS

Sample Name:	No. of frames analysed: 31
Lab. Name: 2000708	No. of particles analysed: 713
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	57,5	29,8	0,5	0,1	5,6	3,8	0,8	0,1	0,3	98,6
Leucoxene	74,2	13,2	0,2	0,4	4,8	4,7	0,3	0,2	0,4	98,3
Rutile	90,4	1,8	0,2	0,1	2,6	2,8	0,2	0,1	0,5	98,6
Ti magnetite	38,1	30,2	0,3	0,9	14,6	8,0	0,7	0,2	1,2	94,1
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	3,9	4,0	0,0	16,8	0,0	3,4	0,4	0,0	28,5
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	6,9	10,4	0,7	0,4	43,3	20,7	0,8	0,4	2,6	86,1
Kya/Sill	0,0	0,8	0,2	0,3	43,0	54,1	0,0	0,1	0,0	98,5
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	0,2	0,1	27,9	0,5	0,1	0,1	61,7	90,9
Silicate	2,0	3,0	0,2	0,3	53,7	35,0	0,5	0,3	0,5	95,4
Unclassified	5,0	5,0	2,4	1,8	13,4	9,7	1,9	4,2	5,7	49,1

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	75,0	12,7	5,8	0,9	1,7	2,8	1,1	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	58,3	75,5	91,7	40,5
Fe_2O_3 wt%	30,2	13,4	1,8	32,1
MnO wt%	0,5	0,2	0,2	0,3
Cr_2O_3 wt%	0,1	0,4	0,1	0,9
SiO_2 wt%	5,7	4,8	2,7	15,5
Al_2O_3 wt%	3,9	4,8	2,8	8,5
MgO wt%	0,8	0,4	0,2	0,7
CaO wt%	0,1	0,2	0,1	0,2
ZrO_2 wt%	0,3	0,4	0,5	1,3
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	62,5
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	60,6
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	55,8	
Leucoxene	9,5	
Rutile	4,3	
Ti magnetite	0,6	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	1,3	
Kya/Sill	0,8	
Staurolite	0,0	
Zircon	2,1	
Silicate	20,2	
Unclassified	5,4	
Total	100,0	

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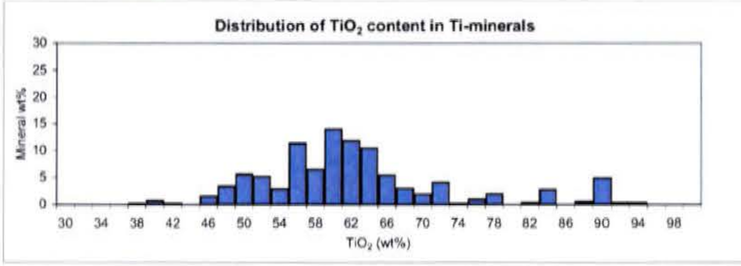
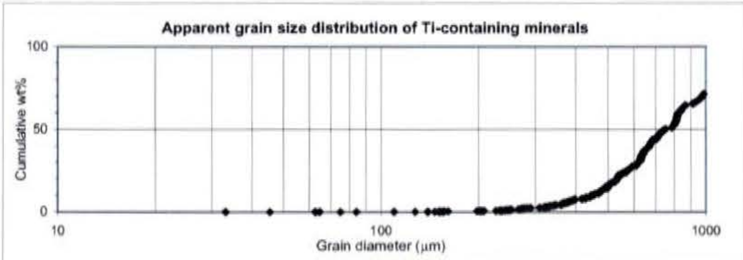
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm^2)	Total grains
Ilmenite	1,5	1,8	2324	888	294429	170
Leucoxene	1,5	1,8	2145	827	242780	35
Rutile	1,8	1,6	2481	891	385478	9
Ti magnetite	1,5	1,7	1120	435	76431	7
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	1,1	1,0	125	49	1299	1
Y-phosphate	0,0	0,0	0	0	0	0
Sphene	0,0	0,0	0	0	0	0
Garnet	1,4	1,7	929	376	67405	19
Kya/Sill	1,7	2,0	2836	1098	334737	3
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,4	1,6	1730	607	183741	10
Silicate	1,5	2,0	1942	791	211968	145
Unclassified	1,4	1,4	432	164	25466	314

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GEUS

Sample Name:	No. of frames analysed 22
Lab. Name: 2000709	No. of particles analysed: 743
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	59,1	34,5	0,5	0,1	1,5	2,0	0,8	0,1	0,2	98,7
Leucoxene	76,1	16,0	0,2	0,3	1,8	3,4	0,4	0,1	0,3	98,7
Rutile	91,5	2,1	0,1	0,3	1,5	2,2	0,1	0,1	0,5	98,4
Ti magnetite	40,5	37,4	0,3	0,1	7,2	2,8	0,5	0,1	8,8	97,7
Magnetite	1,9	67,3	0,2	0,0	16,9	9,5	0,6	0,1	0,7	97,1
Chromite	0,9	38,2	0,1	34,6	0,2	19,2	4,9	0,1	0,0	98,2
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	4,5	11,8	0,2	0,5	42,3	23,0	0,4	0,4	5,3	88,5
Kya/Sill	0,3	0,6	0,1	0,2	42,7	53,9	0,0	0,1	0,2	98,2
Staurolite	5,4	12,3	0,1	0,8	32,3	46,1	1,5	0,0	0,2	98,6
Zircon	0,3	0,4	0,1	0,1	27,7	0,5	0,1	0,1	61,3	90,6
Silicate	0,7	0,9	0,1	0,2	50,0	46,1	0,1	0,1	0,2	98,4
Unclassified	4,5	7,0	0,3	0,3	13,7	11,5	0,6	1,3	22,2	61,5

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	65,0	17,8	5,0	1,3	0,0	6,9	3,8	0,3	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category: Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	59,8	77,1	93,0	41,4
Fe_2O_3 wt%	34,9	16,2	2,1	38,3
MnO wt%	0,6	0,2	0,1	0,3
Cr_2O_3 wt%	0,1	0,3	0,3	0,1
SiO_2 wt%	1,6	1,9	1,6	7,4
Al_2O_3 wt%	2,0	3,4	2,2	2,9
MgO wt%	0,8	0,4	0,1	0,6
CaO wt%	0,1	0,1	0,1	0,1
ZrO_2 wt%	0,2	0,3	0,5	9,0
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	64,9
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	63,2
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	49,6	
Leucoxene	13,6	
Rutile	3,8	
Ti magnetite	1,0	
Magnetite	0,1	
Chromite	0,5	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,0	
Kya/Sill	2,9	
Staurolite	0,2	
Zircon	5,3	
Silicate	21,2	
Unclassified	1,9	
Total	100,0	

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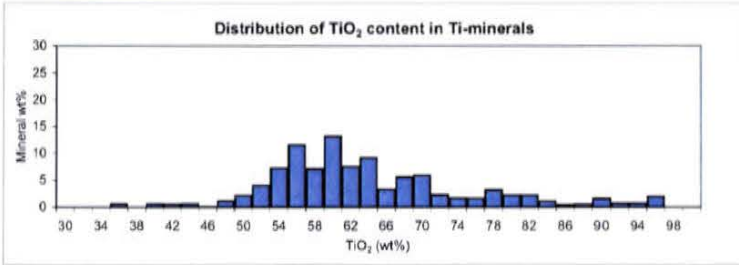
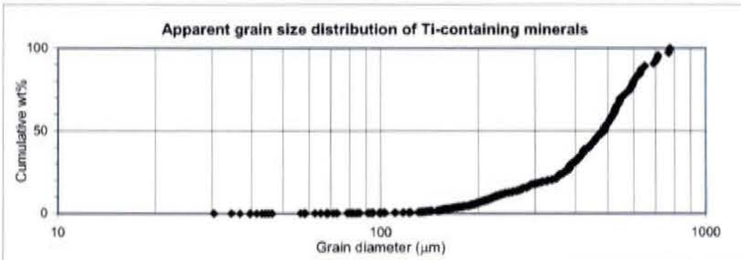
GEUS

Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,6	1,7	1279	475	99182	231
Leucoxene	1,5	1,7	1164	435	82659	76
Rutile	1,7	1,7	908	336	50780	31
Ti magnetite	1,4	2,5	1714	723	104438	4
Magnetite	1,7	2,2	653	266	15725	2
Chromite	1,2	1,6	1955	718	186069	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	1,1	1,3	234	88	3697	2
Kya/Sill	1,7	1,8	1046	399	54043	34
Staurolite	1,4	2,0	1012	403	43314	3
Zircon	1,4	1,5	1048	368	71306	33
Silicate	1,7	1,8	1022	400	63056	263
Unclassified	1,7	1,8	905	356	49346	30

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GEUS

Sample Name:		No. of frames analysed	38
Lab. Name: 2000714		No. of particles analysed:	654
Date:		Heavy minerals in raw sand (%):	0,00
Submitter:			
Country:		Comments:	
Analyzed by:			
Acc. Voltage/Magnification: 17kV/100x			
Guard region:	µm		
Sieve:	100 μm^2		

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	61,5	33,5	0,4	0,1	0,8	1,1	0,8	0,1	0,3	98,6
Leucoxene	75,0	17,9	0,2	0,3	1,9	2,7	0,4	0,1	0,1	98,7
Rutile	95,2	1,2	0,1	0,2	0,4	0,4	0,1	0,1	0,2	97,8
Ti magnetite	43,4	48,8	0,6	0,2	1,0	1,2	1,4	0,1	0,7	97,4
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	0,4	34,7	0,5	0,1	38,0	19,8	5,3	0,9	0,2	99,8
Kya/Sill	0,2	0,6	0,2	0,1	43,1	53,8	0,1	0,0	0,3	98,4
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	27,4	0,2	0,1	0,0	61,5	89,8
Silicate	0,5	0,5	0,1	0,2	45,6	51,9	0,0	0,0	0,1	98,9
Unclassified	9,8	2,1	0,3	0,1	13,2	3,5	0,1	1,3	30,3	60,8

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	46,6	10,1	19,3	0,2	0,1	22,4	1,3	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	62,4	76,0	97,3	44,6
Fe_2O_3 wt%	34,0	18,2	1,2	50,1
MnO wt%	0,4	0,3	0,1	0,6
Cr_2O_3 wt%	0,1	0,3	0,2	0,2
SiO_2 wt%	0,8	1,9	0,5	1,1
Al_2O_3 wt%	1,2	2,7	0,4	1,3
MgO wt%	0,8	0,4	0,1	1,4
CaO wt%	0,1	0,1	0,1	0,1
ZrO_2 wt%	0,3	0,1	0,2	0,7
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	73,0
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	64,7
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	40,8	
Leucoxene	8,8	
Rutile	16,9	
Ti magnetite	0,1	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,1	
Kya/Sill	1,1	
Staurolite	0,0	
Zircon	19,6	
Silicate	9,0	
Unclassified	3,4	
Total	100,0	

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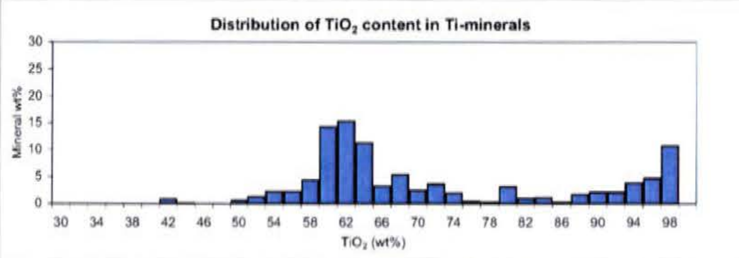
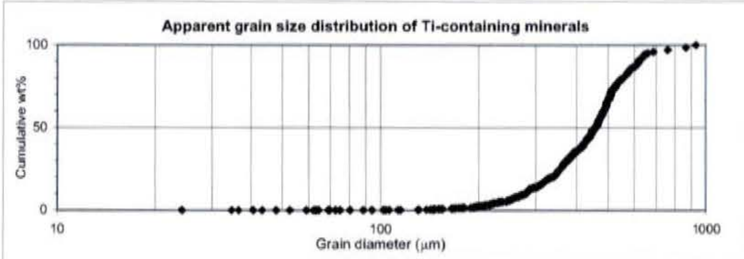
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (μm^2)	Total grains
Ilmenite	1,6	1,8	1447	545	109819	236
Leucoxene	1,6	1,8	1486	561	119084	47
Rutile	1,4	1,6	1372	496	102895	94
Ti magnetite	1,2	1,8	612	243	17688	5
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	1,9	1,9	980	390	46566	2
Kya/Sill	1,6	2,2	1733	713	123961	8
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,5	1,7	1181	441	76802	157
Silicate	1,5	1,9	1670	660	139321	70
Unclassified	1,5	1,7	1277	511	103249	35

Geological Survey of Denmark and Greenland
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GEUS

Sample Name:	No. of frames analysed: 23
Lab. Name: 2000715	No. of particles analysed: 630
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	Comments:
Country:	
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	58,7	35,8	0,6	0,1	0,9	1,4	0,9	0,1	0,2	98,7
Leucoxene	75,7	15,4	0,2	0,2	2,4	3,4	0,5	0,3	0,4	98,4
Rutile	93,2	1,8	0,1	0,4	1,1	1,6	0,1	0,1	0,1	98,6
Ti magnetite	43,1	44,4	0,4	0,2	4,4	1,4	1,3	0,5	2,7	98,4
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	23,0	0,3	0,2	38,8	17,0	1,3	13,3	1,1	96,0
Kya/Sill	0,3	0,7	0,1	0,2	42,7	53,9	0,0	0,1	0,2	98,2
Staurolite	0,5	11,7	0,2	0,1	37,7	45,0	1,3	0,1	0,7	97,4
Zircon	0,2	0,5	0,1	0,1	27,3	0,3	0,1	0,1	61,4	90,0
Silicate	0,9	1,5	0,1	0,1	48,7	45,9	0,4	0,5	0,1	98,3
Unclassified	5,3	7,1	0,5	0,9	12,6	14,7	1,3	11,9	14,6	68,9

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	71,1	9,4	4,9	1,9	0,1	5,4	7,2	0,1	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	59,5	76,9	94,5	43,8
Fe_2O_3 wt%	36,3	15,6	1,8	45,1
MnO wt%	0,6	0,2	0,1	0,5
Cr_2O_3 wt%	0,1	0,2	0,4	0,2
SiO_2 wt%	1,0	2,4	1,1	4,5
Al_2O_3 wt%	1,4	3,5	1,6	1,4
MgO wt%	0,9	0,5	0,1	1,3
CaO wt%	0,1	0,3	0,1	0,5
ZrO_2 wt%	0,2	0,4	0,1	2,7
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	63,0
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	61,1
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	55,4	
Leucoxene	7,3	
Rutile	3,8	
Ti magnetite	1,5	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,1	
Kya/Sill	5,6	
Staurolite	0,1	
Zircon	4,2	
Silicate	20,1	
Unclassified	2,0	
Total	100,0	

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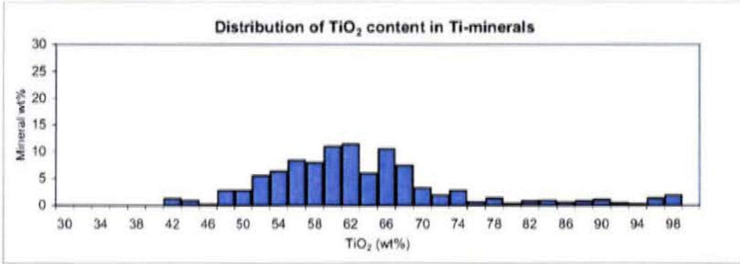
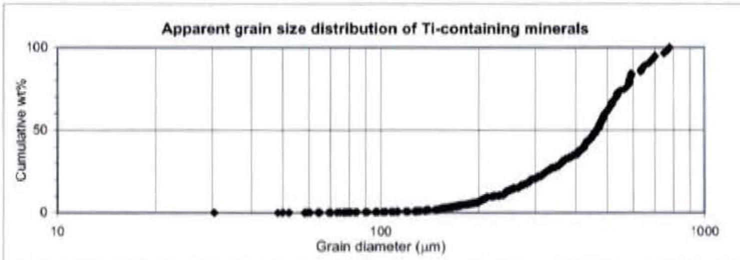
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (µm)	Length (µm)	Area (µm²)	Total grains
Ilmenite	1,6	1,7	1238	465	89970	237
Leucoxene	1,7	1,8	1047	398	62332	45
Rutile	1,7	1,8	1070	411	62807	21
Ti magnetite	1,7	3,0	2436	1070	176229	3
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	1,3	1,7	439	170	11330	4
Kya/Sill	1,8	1,8	1081	426	67732	44
Staurolite	1,6	1,6	586	233	23988	2
Zircon	1,5	1,5	899	317	48602	32
Silicate	1,7	1,9	1026	402	60127	219
Unclassified	1,5	1,8	930	368	54919	23

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GEUS

Sample Name:		No. of frames analysed	29
Lab. Name:	2000716	No. of particles analysed:	589
Date:	20-10-03	Heavy minerals in raw sand (%):	0,00
Submitter:	Stefan Bernstein	Comments:	
Country:	Indien		
Analyzed by:	jk		
Acc. Voltage/Magnification: 17kV/75x			
Guard region:	200 µm		
Sieve:	100 µm²		

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	57,9	35,8	0,7	0,2	1,5	1,8	0,9	0,1	0,1	98,9
Leucoxene	76,1	14,7	0,2	0,4	2,7	3,9	0,4	0,2	0,3	98,8
Rutile	94,4	1,2	0,1	0,3	1,0	1,3	0,1	0,1	0,2	98,7
Ti magnetite	40,9	35,4	0,5	0,0	15,2	2,8	2,6	0,7	0,2	98,5
Magnetite	1,0	67,1	4,1	0,6	12,1	8,5	0,6	1,0	0,3	95,4
Chromite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Pyrite	0,2	29,2	0,2	0,2	5,2	4,2	0,1	0,0	0,5	39,8
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	19,6	0,4	0,0	39,7	21,4	1,8	15,1	0,0	98,3
Kya/Sill	0,3	0,7	0,1	0,2	42,8	53,9	0,0	0,1	0,2	98,4
Staurolite	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Zircon	0,3	0,3	0,1	0,1	27,8	0,5	0,1	0,1	61,7	90,9
Silicate	0,3	1,0	0,1	0,2	49,2	46,8	0,2	0,3	0,2	98,3
Unclassified	7,3	7,1	0,4	0,1	12,8	14,5	1,4	1,3	17,0	61,9

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	59,8	18,3	7,5	0,5	0,5	7,1	6,3	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category: Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	58,6	77,1	95,7	41,5
Fe_2O_3 wt%	36,2	14,9	1,2	36,0
MnO wt%	0,7	0,2	0,1	0,6
Cr_2O_3 wt%	0,2	0,4	0,3	0,0
SiO_2 wt%	1,5	2,7	1,0	15,5
Al_2O_3 wt%	1,8	3,9	1,3	2,9
MgO wt%	0,9	0,4	0,1	2,7
CaO wt%	0,1	0,2	0,1	0,7
ZrO_2 wt%	0,1	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:	65,6
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	62,7
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	43,3	
Leucoxene	13,2	
Rutile	5,4	
Ti magnetite	0,4	
Magnetite	0,1	
Chromite	0,0	
Pyrite	0,4	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,4	
Kya/Sill	4,6	
Staurolite	0,0	
Zircon	5,1	
Silicate	24,1	
Unclassified	2,9	
Total	100,0	

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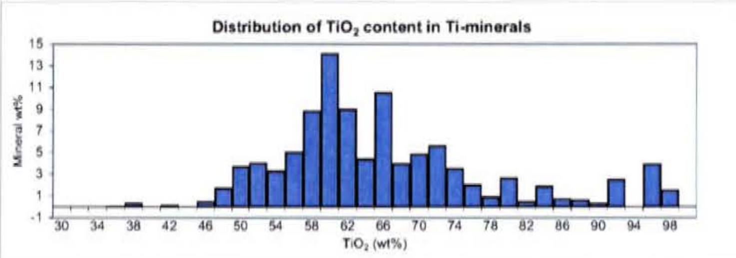
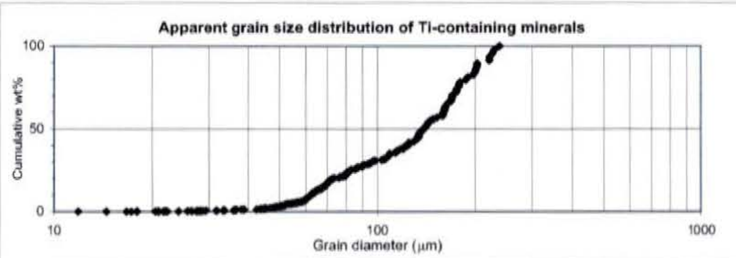
GEUS

Lab. Name:	2000716	Analyzed by:	jk
Submitter:	Stefan Bernstein	Acc. Voltage	17kV
Date:	20-10-03		





Average grain parameters						
Category	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm^2)	Total grains
Ilmenite	1,6	1,7	331	123	6898	193
Leucoxene	1,6	1,7	365	136	7980	51
Rutile	1,6	1,6	374	136	7898	19
Ti magnetite	2,1	1,9	213	87	2213	5
Magnetite	1,6	1,9	210	83	1871	2
Chromite	0,0	0,0	0	0	0	0
Pyrite	1,3	3,0	457	199	5527	2
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	2,1	2,0	247	97	2615	5
Kya/Sill	1,7	2,0	353	141	5749	34
Staurolite	0,0	0,0	0	0	0	0
Zircon	1,4	1,5	270	91	5085	30
Silicate	1,7	1,9	318	126	5656	222
Unclassified	1,5	1,9	328	129	5805	26

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GEUS

Sample Name:	No. of frames analysed: 144
Lab. Name: 2000717	No. of particles analysed: 1727
Date:	Heavy minerals in raw sand (%): 0,00
Submitter:	
Country:	Comments:
Analyzed by:	
Acc. Voltage/Magnification: 17kV/100x	
Guard region: µm	
Sieve: 100 µm²	

	Average content									
Category	TiO_2 wt%	Fe_2O_3 wt%	MnO wt%	Cr_2O_3 wt%	SiO_2 wt%	Al_2O_3 wt%	MgO wt%	CaO wt%	ZrO_2 wt%	Total
Ilmenite	59,5	33,6	0,5	0,1	1,7	2,1	0,9	0,1	0,2	98,7
Leucoxene	75,1	16,5	0,2	0,3	2,1	3,7	0,5	0,1	0,2	98,8
Rutile	92,5	1,8	0,1	0,3	1,3	1,9	0,1	0,1	0,4	98,6
Ti magnetite	39,9	30,8	0,4	0,1	12,1	14,5	0,5	0,1	0,4	98,8
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	27,1	5,9	0,1	0,4	34,6	19,8	0,5	0,2	2,2	90,9
Kya/Sill	0,3	0,5	0,1	0,2	42,8	53,9	0,0	0,1	0,2	98,2
Staurolite	1,8	8,4	0,0	0,3	42,0	43,5	0,2	0,5	1,0	97,7
Zircon	0,2	0,3	0,1	0,1	27,6	0,3	0,1	0,0	61,8	90,6
Silicate	0,9	1,3	0,1	0,2	48,8	46,3	0,2	0,1	0,2	98,2
Unclassified	9,1	6,5	1,8	1,1	14,6	16,3	0,7	1,7	14,7	66,5

Valuable heavy minerals									
Category	Ilmenite	Leucoxene	Rutile	Ti magnetite	Garnet	Zircon	Kya/Sill	Staurolite	Total
wt %	57,9	18,3	7,3	1,2	0,0	5,6	9,7	0,0	100,0

Normalised average contents of the valuable Ti-containing minerals:				
Average content	Category			
	Ilmenite	Leucoxene	Rutile	Ti magnetite
TiO_2 wt%	60,3	76,1	93,9	40,4
Fe_2O_3 wt%	34,0	16,7	1,8	31,1
MnO wt%	0,5	0,2	0,1	0,4
Cr_2O_3 wt%	0,2	0,3	0,3	0,1
SiO_2 wt%	1,7	2,1	1,3	12,2
Al_2O_3 wt%	2,1	3,7	2,0	14,7
MgO wt%	0,9	0,5	0,1	0,5
CaO wt%	0,1	0,1	0,1	0,1
ZrO_2 wt%	0,2	0,2	0,4	0,4
Total	100,0	100,0	100,0	100,0

Average TiO_2 content of all the TiO_2 minerals:	66,3
Average TiO_2 content of all the TiO_2 minerals excl. rutile:	63,7
Valuable heavy minerals in raw sand:	0,00

Weight percent on a mineral basis:		
Category	Heavy mineral concentrate wt %	Raw sand wt %
Ilmenite	41,4	
Leucoxene	13,1	
Rutile	5,2	
Ti magnetite	0,8	
Magnetite	0,0	
Chromite	0,0	
Pyrite	0,0	
Phosphate	0,0	
Monazite	0,0	
Y-phosphate	0,0	
Sphene	0,0	
Garnet	0,0	
Kya/Sill	7,0	
Staurolite	0,0	
Zircon	4,0	
Silicate	26,8	
Unclassified	1,6	
Total	100,0	

Geological Survey of Denmark and Greenland
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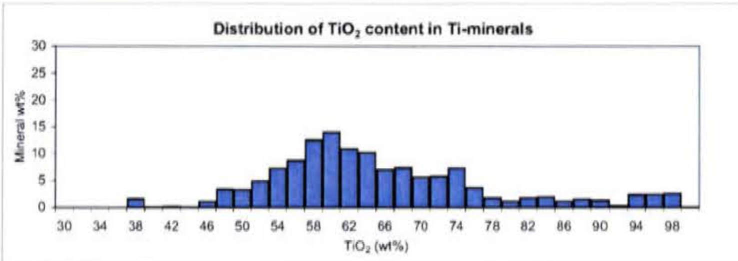
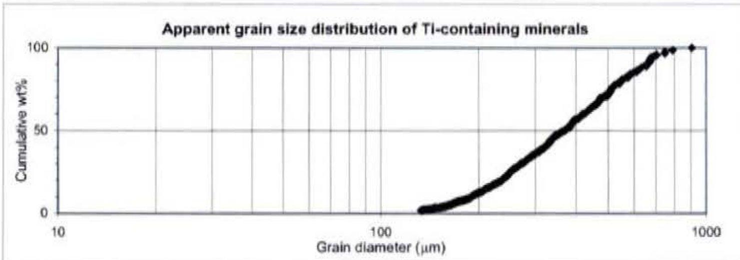
Lab. Name:	0	Analyzed by:	0
Submitter:	00-01-00	Acc. Voltage	17kV
Date:	00-01-00		





Category	Average grain parameters					Total grains
	Aspect ratio	Circularity	Perimeter (μm)	Length (μm)	Area (μm²)	
Ilmenite	1,6	1,7	1032	383	64429	502
Leucoxene	1,6	1,7	979	361	55812	177
Rutile	1,5	1,6	892	323	48369	76
Ti magnetite	1,5	2,2	1268	529	72457	9
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	1,3	311	113	7320	4
Kya/Sill	1,6	2,0	1314	531	78871	97
Staurolite	1,7	2,0	478	191	9073	1
Zircon	1,5	1,5	815	283	41102	70
Silicate	1,6	1,8	949	368	51007	693
Unclassified	1,5	1,6	712	273	35740	59

Table 1, CCSEM summary		Average ilmenite compositions				
GEUS sample#	Indian sample#	av. TiO2	av. MgO	av. Al2O3	av. SiO2	av. aspct
2002 sample collection		wt. %	wt. %	wt. %	wt. %	
10	K3	52.8	0.4	1.2	0.8	1.7
12	K5	62.6	0.4	0.5	0.5	1.7
15	K8	61.2	0.5	0.7	0.6	1.5
18	K12	61.2	0.3	0.9	0.6	1.8
19	K14	61.2	0.5	0.5	0.5	1.7
20	K15	59.0	0.5	0.5	0.5	1.7
25	K24	52.1	0.6	0.8	0.6	1.6
26	K25	52.2	0.9	0.8	0.4	1.6
27	K26	51.4	0.8	0.8	0.4	1.6
28	K27	59.2	0.9	0.7	0.4	1.5
29	K28	60.2	0.9	0.9	0.5	1.5
30	K29	59.4	0.9	0.7	0.5	1.5
31	K30	52.9	0.8	1.3	0.9	1.6
33	K32	56.6	0.9	1.2	0.7	1.6
35	K34	55.2	1.0	1.1	1.0	1.6
38	K38	60.2	1.0	1.0	0.7	1.6
39	K39	52.6	0.9	0.9	0.6	1.5
40	K40	51.4	1.0	0.7	0.5	1.6
45	K45	53.5	0.7	0.4	0.6	1.5
48	K48	53.0	0.8	0.7	0.5	1.5
50	K50	50.5	0.9	0.6	0.5	1.5
53	K53	49.6	0.8	0.7	0.7	1.5
55	K55	50.3	0.7	0.6	0.7	1.5
62	K65		0.6	0.8	0.8	1.5
65	K68	60.9	0.8	1.4	0.9	1.5
67	K72	60.2	0.6	1.1	0.8	1.6
69	K80	62.0	0.7	0.5	0.8	1.6
70	K81	61.1	0.6	0.8	0.8	1.5
74	K87	60.3	0.7	1.1	0.9	1.5
2003 sample collection, Chavara Segment		59.6				
668	2	59.3	0.9	0.8	0.4	1.6
672	5	59.2	0.9	0.7	0.4	1.5
676	7	59.2	0.9	0.8	0.4	1.5
677	8	60.5	0.9	0.8	0.4	1.6
679	9	60.9	0.9	0.7	0.4	1.6
680	9A	60.7	0.8	0.9	0.6	1.5
681	9B	61.5	0.8	1.4	1.0	1.6
682	9C	60.8	0.9	1.2	0.9	1.5
683	9D	59.8	0.8	1.1	0.6	1.6
692	14	60.3	0.9	0.7	0.3	1.5
693	14A	58.3	0.9	0.8	0.4	1.6
694	14B	59.8	0.9	0.7	0.4	1.6
696	14C	62.4	0.9	1.1	0.6	1.6
695	14D	59.5	0.8	1.2	0.8	1.6
706	20	58.6	0.9	0.9	0.4	1.6
707	20A	60.3	0.9	1.4	0.8	1.6
708	20B		0.9	1.9	1.7	1.5
709	20C		0.8	1.5	0.8	1.6
714	22		0.8	0.9	0.5	1.6
715	22A		0.9	1.2	0.8	1.6
716	22B		0.9	1.4	0.9	1.6
717	22C		0.9	1.5	0.9	1.6

Table 1, CCSEM		Average garnet compositions				
GEUS sample#	av. length	av. gross	av. pyrope	av. al+sp	av. aspect	av. length
2002 sample colle	micrometer	%	%	%		micrometer
10	138	9.0	24.5	66.5	1.7	233
12	126	12.6	21.3	66.1	1.8	167
15	268	16.6	15.9	67.5	1.7	347
18	189	7.8	17.0	75.2	1.9	266
19	197	8.8	21.0	70.3	1.7	287
20	110	7.0	21.9	71.0	1.8	139
25	129	8.2	22.2	69.6	2.0	169
26	253	3.1	35.2	61.7	1.7	377
27	253					
28	264					
29	261	2.6	30.8	66.6	1.6	349
30	393					
31	317	3.0	28.3	68.7	1.7	414
33	315	3.1	27.5	69.4	1.7	459
35	392	3.3	26.8	69.9	1.6	632
38	242	2.1	24.3	73.6	1.7	273
39	245	2.4	27.9	69.6	2.0	367
40	252	2.1	28.7	69.1	1.7	424
45	482	4.2	23.2	72.7	1.5	645
48	272	3.3	26.2	70.6	1.7	396
50	298	3.6	25.8	70.7	2.0	575
53	220	4.5	23.8	71.6	1.8	305
55	322	3.4	25.9	70.7	1.8	508
62	265					
65	159	2.9	34.0	63.1	2.0	197
67	221	2.6	30.9	66.4	1.7	118
69	244	5.5	27.6	67.0	1.7	321
70	262	5.1	28.2	66.7	1.7	311
74	227	6.0	28.5	65.5	2.0	208
2003 sample colle						
668	293	2.4	30.7	66.8	1.9	444
672	236					
676	332	2.5	28.6	68.9	1.6	440
677	226					
679	707					
680	261					
681	211					
682	169					
683	437	7.3	23.4	69.2	2.0	536
692	277					
693	290	2.0	31.3	66.7	1.9	149
694	241	2.4	29.7	68.0	1.5	519
696	563					
695	575					
706	542					
707	224					
708	903					
709	483					
714	551					
715	474					
716	130					
717	399					

Table 2, mode and bulk composition				modal composition of heavy mineral separate					
GEUS-sample#	Indian sample#	type	average TiO2 in ilmenite	Ilmenite	Leucoxene	Rutile	Ti magnetite	Magnetite	Chromite
10	K3	river	50.0	5.79	.52	.10	8.07	11.05	.02
11	K4	beach							
12	K5	beach	50.4	14.20	.20	2.20	6.30	6.40	.10
13	K6	river							
15	K8	beach	53.0	26.10	.40	10.20	15.30	20.00	1.00
18	K12	river	51.9	4.40	.00	.00	11.40	3.20	.00
19	K14	beach	50.2	11.10	.00	.00	23.20	7.90	.00
20	K15	beach	51.1	9.37	.36	.28	5.42	7.55	.00
25	K24	beach	52.8	4.91	.48	.00	2.80	.80	.00
26	K25	beach	62.6	58.10	17.90	3.20	.20	.50	.00
27	K26	beach	61.2	80.17	11.36	2.19	.00	.00	.00
28	K27	beach	61.2	76.35	7.58	4.58	.39	.00	.00
29	K28	beach	61.2	46.90	5.90	7.10	.50	.00	.00
30	K29	beach	59.0	73.03	2.74	1.53	.91	.65	.00
31	K30	river	52.1	14.40	2.80	.10	35.30	1.40	.00
33	K32	river	52.2	14.11	.79	.00	15.09	1.40	.00
35	K34	river	51.4	11.10	2.40	1.70	16.20	6.00	.00
38	K38	beach	59.2	60.55	3.71	2.06	2.37	1.89	.00
39	K39	beach	60.2	62.80	6.90	2.90	1.40	2.70	.00
40	K40	beach	59.4	66.60	7.34	2.63	1.47	.14	.18
42	K42	river							
45	K45	beach	52.9	44.40	.00	.00	4.70	.00	.00
46	K46	beach							
47	K47	beach							
48	K48	beach	56.6	52.30	4.40	3.90	3.50	.00	.00
49	K49	beach							
50	K50	beach	55.2	65.00	.50	.60	3.10	.00	.00
52	K52	beach							
53	K53	river	60.2	20.70	2.30	5.60	4.20	.00	.00
54	K54	Teri							
55	K55	river	52.6	12.50	1.10	.50	.00	.10	.00
58	K59	beach							
60	K62	Teri							
61	K64	beach							
62	K65	Teri	51.4	81.20	1.60	2.90	6.50	.00	.00
65	K68	Teri	53.5	24.20	.60	3.10	10.20	.30	.00
66	K70	Teri							
67	K72	Teri	53.0	58.90	2.90	5.60	3.80	2.80	.00
68	K74	Teri							
69	K80	beach	50.5	26.60	1.40	.10	12.30	1.10	.00
70	K81	Teri	49.6	46.00	.80	2.30	37.20	3.00	.00
71	K82	Teri							
72	K83	Teri							
73	K86	Teri							
74	K87	beach	50.3	47.70	.30	2.40	28.70	.90	.00
668	2	beach	60.9	76.48	6.39	3.40	.00	.00	.05
672	5	beach	60.2	76.69	4.15	5.79	.00	.00	.14
676	7	beach	62.0	73.04	6.85	2.43	.14	.00	.00
677	8	beach	61.1	66.13	18.18	2.97	.00	.00	.00
679	9	beach	60.3	64.39	6.51	2.02	.63	.00	.00
680	9A	lagoon	59.6	74.91	4.31	5.81	.39	.00	.00
681	9B	lagoon	59.3	64.61	5.83	4.10	.42	.05	.00
682	9C	lagoon	59.2	56.25	7.21	7.73	1.35	.00	.00
683	9D	lagoon	59.2	57.21	10.88	5.08	1.32	.19	.00
692	14	beach	60.5	77.74	4.50	5.28	.48	.00	.00
693	14A	lagoon	60.9	63.94	6.40	4.44	1.24	.00	.00
694	14B	lagoon	60.7	73.00	6.99	3.69	.28	.02	.00
695	14C	lagoon	61.5	54.71	11.75	3.22	.00	.79	.00
696	14D	lagoon	60.8	51.44	13.87	4.07	.87	.00	.00
706	20	beach	59.8	67.23	4.89	6.18	.00	.00	.00
707	20A	lagoon	60.3	61.17	13.73	4.83	.09	.00	.00
708	20B	lagoon	58.3	55.84	9.48	4.30	.63	.00	.00
709	20C	lagoon	59.8	49.63	13.61	3.79	.96	.08	.46
714	22	beach	62.4	40.80	8.81	16.92	.15	.00	.00
715	22A	lagoon	59.5	55.37	7.28	3.81	1.46	.00	.00
716	22B	lagoon	58.6	43.31	13.24	5.42	.38	.14	.00
717	22C	lagoon	60.3	41.41	13.12	5.20	.84	.00	.00

Table 2, mode an											
GEUS-sample#	Pyrite	Phosphate	Monazite	Y-phosphate	Sphene	Garnet	Kya/Sill	Staurolite	Zircon	Silicate	Unclassified
10	.00	.13	.01	.00	.60	17.51	1.49	.11	1.51	47.94	5.13
11											
12	.00	.10	.40	.00	.00	18.40	4.00	.00	.90	45.00	1.90
13											
15	.00	.00	.00	.00	.00	3.60	5.10	.00	12.60	4.10	1.70
18	.00	1.40	.00	.00	.00	7.80	.10	.00	1.00	66.80	3.90
19	.00	.90	.30	.00	.00	12.10	.00	.00	3.60	39.60	1.2
20	.00	2.52	.45	.00	1.17	5.62	.00	.00	2.03	60.47	4.75
25	.00	1.13	.00	.00	.10	10.65	.51	.00	.16	75.56	2.88
26	.00	.00	.00	.00	.00	1.70	7.00	.40	1.00	9.00	.90
27	.00	.00	.15	.00	.00	.00	1.40	.00	1.69	2.58	.45
28	.00	.00	.23	.00	.00	.11	1.49	.37	3.74	4.92	.24
29	.00	.00	4.60	.00	.00	.70	4.10	.00	21.80	6.60	1.80
30	.00	.00	2.43	.00	.00	.58	.79	.00	12.57	2.43	2.33
31	.00	.00	2.00	.00	.00	35.80	1.90	.00	.10	4.90	1.30
33	.00	.00	.11	.00	.00	51.95	1.31	.00	.05	11.32	3.86
35	.00	.00	.00	.00	.00	50.60	.20	.00	.00	8.30	3.50
38	.00	.00	1.81	.00	.00	1.13	7.88	.00	4.30	11.36	2.94
39	.00	.00	.90	.00	.00	4.60	4.60	.30	5.40	6.80	.60
40	.00	.00	2.30	.00	.00	4.59	1.69	.00	5.49	3.59	3.97
42											
45	.00	.00	.70	.00	.00	42.60	.00	.00	2.00	.70	4.80
46											
47											
48	.00	.00	2.80	.00	.00	15.50	2.40	.00	10.20	2.30	2.60
49											
50	.00	.00	7.70	.10	.00	16.40	.10	.00	4.70	.60	1.20
52											
53	.00	.00	4.70	.00	.00	25.10	1.40	.00	23.00	4.10	9.10
54											
55	.00	.00	.30	.00	.00	78.70	1.90	.30	.20	4.00	.40
58											
60											
61											
62	.00	.00	2.40	.00	.00	.00	.00	.00	4.60	.20	.50
65	.00	.00	.10	.00	.00	1.70	15.30	.90	1.30	39.80	2.30
66											
67	.00	.00	.10	.00	.00	.30	4.70	1.10	1.80	15.60	2.40
68											
69	.00	.30	.00	.00	.00	44.30	.00	.00	1.00	9.90	2.90
70	.00	.00	1.20	.00	.20	5.40	.20	.00	2.10	.60	1.00
71											
72											
73											
74	.00	.00	.10	.00	.00	1.00	3.40	.40	2.40	11.10	1.70
668	.00	.00	.00	.00	.00	2.84	.93	.55	3.86	4.61	.87
672	.00	.00	.00	.00	.00	.00	.00	.01	7.91	3.46	1.84
676	.00	.00	.00	.00	.00	2.99	1.50	.16	.39	11.27	1.23
677	.00	.00	.00	.00	.00	.00	1.25	.00	2.25	8.11	1.10
679	.00	.00	.00	.00	.00	.00	1.67	.00	3.32	19.97	1.49
680	.00	.00	.00	.00	.00	.01	.72	.00	10.09	2.59	1.15
681	.00	.00	.00	.00	.00	.30	2.82	.00	3.29	16.90	1.67
682	.00	.00	.00	.00	.00	.09	3.21	.00	4.30	18.20	1.66
683	.04	.00	.00	.00	.00	1.25	1.69	.04	3.79	15.68	2.82
692	.00	.00	.00	.00	.00	.00	.95	.00	6.46	3.40	1.20
693	.00	.00	.00	.00	.00	.18	1.33	.09	2.51	17.37	2.50
694	.00	.00	.00	.00	.00	3.91	.41	.01	3.55	6.94	1.20
695	.00	.00	.00	.00	.00	.21	4.31	.14	2.75	19.60	2.51
696	.00	.00	.00	.00	.00	.15	1.03	.00	1.31	25.42	1.84
706	.00	.00	.00	.00	.00	.09	.43	.00	16.47	2.24	2.48
707	.00	.00	.00	.00	.00	.02	2.38	.00	2.65	14.07	1.05
708	.00	.00	.00	.00	.00	1.27	.81	.00	2.12	20.19	5.35
709	.00	.00	.00	.00	.00	.01	2.87	.24	5.27	21.16	1.92
714	.00	.00	.00	.00	.00	.13	1.13	.00	19.61	9.04	3.41
715	.00	.00	.00	.00	.00	.10	5.59	.11	4.17	20.14	1.97
716	.40	.00	.00	.00	.00	.38	4.59	.00	5.13	24.05	2.95
717	.00	.00	.00	.00	.00	.03	6.96	.01	3.98	26.83	1.61

Table 2, mode an		modal composition of bulk sample								
GEUS-sample#	heavy fraction	Ilmenite	Leucoxene	Rutile	Ti magnetite	Magnetite	Chromite	Pyrite	Phosphate	Monazite
10	17.70	1.02	.09	.02	1.43	1.95	.00	.00	.02	.00
11										
12	24.77	3.52	.05	.54	1.56	1.59	.02	.00	.02	.10
13										
15	76.99	20.09	.31	7.85	11.78	15.40	.77	.00	.00	.00
18	9.99	.44	.00	.00	1.14	.32	.00	.00	.14	.00
19	35.04	3.89	.00	.00	8.13	2.77	.00	.00	.32	.11
20	56.05	5.25	.20	.16	3.04	4.23	.00	.00	1.41	.25
25	11.41	.56	.05	.00	.32	.09	.00	.00	.13	.00
26	95.90	55.72	17.17	3.07	.19	.48	.00	.00	.00	.00
27	97.72	78.34	11.10	2.14	.00	.00	.00	.00	.00	.14
28	85.00	64.90	6.44	3.89	.33	.00	.00	.00	.00	.20
29	95.47	44.78	5.63	6.78	.48	.00	.00	.00	.00	4.39
30	87.64	64.01	2.40	1.34	.80	.57	.00	.00	.00	2.13
31	7.15	1.03	.20	.01	2.52	.10	.00	.00	.00	.14
33	14.24	2.01	.11	.00	2.15	.20	.00	.00	.00	.02
35	9.01	1.00	.22	.15	1.46	.54	.00	.00	.00	.00
38	21.69	13.13	.80	.45	.51	.41	.00	.00	.00	.39
39	39.21	24.62	2.71	1.14	.55	1.06	.00	.00	.00	.35
40	86.96	57.92	6.38	2.29	1.27	.12	.16	.00	.00	2.00
42										
45	70.29	31.21	.00	.00	3.30	.00	.00	.00	.00	.49
46										
47										
48	96.35	50.39	4.24	3.76	3.37	.00	.00	.00	.00	2.70
49										
50	92.61	60.20	.46	.56	2.87	.00	.00	.00	.00	7.13
52										
53	44.00	9.11	1.01	2.46	1.85	.00	.00	.00	.00	2.07
54										
55	27.44	3.43	.30	.14	.00	.03	.00	.00	.00	.08
58										
60										
61										
62	89.50	72.67	1.43	2.60	5.82	.00	.00	.00	.00	2.15
65	6.30	1.52	.04	.20	.64	.02	.00	.00	.00	.01
66										
67	5.30	3.12	.15	.30	.20	.15	.00	.00	.00	.01
68										
69	73.50	19.55	1.03	.07	9.04	.81	.00	.00	.22	.00
70	36.90	16.97	.30	.85	13.73	1.11	.00	.00	.00	.44
71										
72										
73										
74	78.90	37.64	.24	1.89	22.64	.71	.00	.00	.00	.08
668	92.47	70.72	5.91	3.14	.00	.00	.05	.00	.00	.00
672	95.97	73.60	3.99	5.56	.00	.00	.13	.00	.00	.00
676	73.97	54.03	5.07	1.80	.10	.00	.00	.00	.00	.00
677	92.88	61.42	16.88	2.76	.00	.00	.00	.00	.00	.00
679	49.13	31.64	3.20	.99	.31	.00	.00	.00	.00	.00
680	92.79	69.51	4.00	5.39	.37	.00	.00	.00	.00	.00
681	19.92	12.87	1.16	.82	.08	.01	.00	.00	.00	.00
682	12.62	7.10	.91	.98	.17	.00	.00	.00	.00	.00
683	10.15	5.80	1.10	.52	.13	.02	.00	.00	.00	.00
692	93.85	72.96	4.22	4.95	.45	.00	.00	.00	.00	.00
693	46.61	29.80	2.99	2.07	.58	.00	.00	.00	.00	.00
694	76.35	55.73	5.34	2.82	.21	.02	.00	.00	.00	.00
695	7.40	4.05	.87	.24	.00	.06	.00	.00	.00	.00
696	10.60	5.45	1.47	.43	.09	.00	.00	.00	.00	.00
706	84.52	56.83	4.13	5.22	.00	.00	.00	.00	.00	.00
707	11.42	6.99	1.57	.55	.01	.00	.00	.00	.00	.00
708	9.04	5.05	.86	.39	.06	.00	.00	.00	.00	.00
709	15.49	7.69	2.11	.59	.15	.01	.07	.00	.00	.00
714	74.63	30.45	6.58	12.63	.11	.00	.00	.00	.00	.00
715	12.15	6.73	.89	.46	.18	.00	.00	.00	.00	.00
716	7.81	3.38	1.03	.42	.03	.01	.00	.03	.00	.00
717	9.38	3.88	1.23	.49	.08	.00	.00	.00	.00	.00

Table 2, mode an									bulk composition		
GEUS-sample#	Y-phosphate	Sphene	Garnet	Kya/Sill	Staurolite	Zircon	Silicate	Unclassified	Fe2O3 wt%	TiO2 wt%	MgO wt%
10	.00	.11	3.10	.26	.02	.27	90.79	.91	8.8	2.0	2.2
11									2.5	.8	1.3
12	.00	.00	4.56	.99	.00	.22	86.38	.47	6.5	3.7	2.4
13									5.8	.8	1.6
15	.00	.00	2.77	3.93	.00	9.70	26.17	1.31	20.8	21.4	.9
18	.00	.00	.78	.01	.00	.10	96.68	.39	3.5	.5	1.4
19	.00	.00	4.24	.00	.00	1.26	78.84	.42	11.4	5.3	2.7
20	.00	.65	3.15	.00	.00	1.14	77.84	2.66	14.2	5.9	5.0
25	.00	.01	1.22	.06	.00	.02	97.21	.33	2.8	.7	1.8
26	.00	.00	1.63	6.71	.38	.96	12.73	.86	12.6	51.3	1.1
27	.00	.00	.00	1.37	.00	1.65	4.80	.44	15.3	61.9	1.0
28	.00	.00	.09	1.27	.32	3.18	19.18	.21	13.8	46.9	1.1
29	.00	.00	.67	3.91	.00	20.81	10.83	1.72	9.6	35.4	1.0
30	.00	.00	.51	.69	.00	11.02	14.49	2.04	15.2	45.0	1.0
31	.00	.00	2.56	.14	.00	.01	93.20	.09	4.1	1.2	.3
33	.00	.00	7.40	.19	.00	.01	87.37	.55	6.9	2.9	.7
35	.00	.00	4.56	.02	.00	.00	91.74	.32	7.7	1.2	.4
38	.00	.00	.25	1.71	.00	.93	80.77	.64	3.6	6.4	.6
39	.00	.00	1.80	1.80	.12	2.12	63.46	.24	8.1	14.6	.6
40	.00	.00	4.00	1.47	.00	4.78	16.16	3.45	14.7	41.8	1.1
42									4.3	1.1	.4
45	.00	.00	29.94	.00	.00	1.41	30.20	3.37	18.7	14.6	2.1
46									7.2	13.3	1.4
47									12.4	16.0	1.7
48	.00	.00	14.93	2.31	.00	9.83	5.87	2.51	19.0	38.8	1.9
49									5.4	2.0	1.1
50	.09	.00	15.19	.09	.00	4.35	7.95	1.11	18.2	37.8	1.5
52									9.6	13.1	1.2
53	.00	.00	11.04	.62	.00	10.12	57.80	4.00	4.2	5.3	1.8
54									2.5	2.8	.2
55	.00	.00	21.60	.52	.08	.05	73.66	.11	10.7	3.1	1.3
58									3.5	4.7	1.7
60									15.7	24.3	.7
61									11.4	12.9	1.5
62	.00	.00	.00	.00	.00	4.12	10.68	.45	28.0	42.8	.8
65	.00	.00	.11	.96	.06	.08	96.21	.14	1.5	1.4	.3
66									2.8	3.5	.3
67	.00	.00	.02	.25	.06	.10	95.53	.13	2.3	2.2	.2
68									3.0	3.1	.2
69	.00	.00	32.56	.00	.00	.74	33.78	2.13	21.3	12.3	3.7
70	.00	.07	1.99	.07	.00	.77	63.32	.37	14.1	13.8	.6
71									1.9	1.5	.2
72									3.6	.9	.5
73									5.5	3.7	.4
74	.00	.00	.79	2.68	.32	1.89	29.86	1.34	29.9	24.1	2.6
668	.00	.00	2.63	.86	.51	3.57	11.80	.81			
672	.00	.00	.00	.00	.01	7.59	7.35	1.77			
676	.00	.00	2.21	1.11	.12	.29	34.36	.91			
677	.00	.00	.00	1.16	.00	2.09	14.65	1.02			
679	.00	.00	.00	.82	.00	1.63	60.68	.73			
680	.00	.00	.01	.67	.00	9.37	9.62	1.07			
681	.00	.00	.06	.56	.00	.66	83.44	.33			
682	.00	.00	.01	.41	.00	.54	89.68	.21			
683	.00	.00	.13	.17	.00	.38	91.45	.29			
692	.00	.00	.00	.89	.00	6.07	9.34	1.12			
693	.00	.00	.08	.62	.04	1.17	61.49	1.17			
694	.00	.00	2.98	.31	.01	2.71	28.95	.91			
695	.00	.00	.02	.32	.01	.20	94.05	.19			
696	.00	.00	.02	.11	.00	.14	92.10	.19			
706	.00	.00	.07	.36	.00	13.92	17.37	2.09			
707	.00	.00	.00	.27	.00	.30	90.19	.12			
708	.00	.00	.11	.07	.00	.19	92.78	.48			
709	.00	.00	.00	.45	.04	.82	87.79	.30			
714	.00	.00	.10	.84	.00	14.64	32.12	2.55			
715	.00	.00	.01	.68	.01	.51	90.29	.24			
716	.00	.00	.03	.36	.00	.40	94.07	.23			
717	.00	.00	.00	.65	.00	.37	93.14	.15			

Table 2, mode an									trace eleme	
GEUS-sample#	Na2O wt%	P2O5 wt%	K2O wt%	CaO wt%	MnO wt%	SiO2 wt%	Al2O3 wt%	Sum (major+minor)	V	Sc
10	.9	.1	.9	2.0	.1	67.7	10.7	95.67	176	19
11	2.4	.1	.8	1.7	.0	85.4	4.5	99.64	48	6
12	1.7	.1	.5	2.2	.1	80.3	5.4	103.34	159	15
13	1.6	.1	.6	1.6	.1	78.4	7.2	97.93	96	13
15	.0	.0	.1	1.4	.2	46.5	5.1	99.52	453	26
18	3.0	.1	3.0	3.2	.0	69.5	11.0	95.53	53	9
19	3.9	.3	1.8	3.7	.2	65.3	6.8	102.13	263	24
20	2.1	1.0	1.4	6.8	.2	57.8	6.5	101.77	299	41
25	3.8	.1	1.4	3.8	.0	79.6	5.8	100.03	49	8
26	bd	.2	.0	.3	.1	29.4	12.5	108.24	723	70
27	bd	.2	.0	.2	.2	25.5	4.6	109.59	629	61
28	bd	.1	.0	.8	.1	38.8	5.1	108.26	584	48
29	bd	1.6	.0	.5	.1	31.5	6.8	90.75	382	32
30	bd	.7	.0	.3	.1	35.1	1.7	101.63	483	37
31	.3	.0	1.1	.2	.1	88.7	4.6	100.65	55	9
33	.6	.1	1.5	.4	.1	80.7	6.7	100.73	132	16
35	.3	.1	1.4	.3	.1	77.1	9.1	97.83	88	14
38	.1	.1	.1	.5	.0	85.2	2.7	100.08	201	14
39	bd	.1	.1	.1	.1	77.8	4.1	106.19	376	28
40	bd	.7	.0	.2	.1	38.4	4.4	103.59	518	42
42	.7	.1	1.9	.6	.0	80.5	8.4	98.16	65	6
45	.1	.1	.2	9.3	.2	48.5	3.4	97.66	353	48
46	bd	.4	.1	20.2	.1	49.7	2.1	96.37	378	19
47	.1	.3	.1	14.9	.1	51.1	2.5	100.52	421	32
48	bd	.6	.0	.8	.2	30.8	6.5	100.76	492	41
49	.1	.0	.2	4.4	.1	83.4	4.2	100.96	90	16
50	bd	1.4	.0	.7	.1	31.3	2.5	96.32	445	32
52	.0	.1	.1	2.8	.1	73.7	4.4	105.78	378	30
53	bd	.5	.7	25.0	.0	54.7	3.1	97.65	150	9
54	.0	.0	.1	.0	.0	93.2	2.8	101.86	77	4
55	.7	.1	2.5	1.3	.1	76.0	7.4	103.58	124	29
58	.6	.2	.5	29.6	.0	52.9	3.7	97.83	176	7
60	bd	.3	.7	.3	.1	60.6	3.4	107.37	473	33
61	.0	.2	.5	13.6	.1	58.2	2.3	101.66	366	30
62	bd	.6	.1	.1	.1	34.8	1.3	110.66	481	34
65	.3	.0	1.6	.4	.0	90.2	5.4	101.29	60	2
66	.0	.0	.1	.1	.0	94.7	2.2	103.80	103	6
67	.0	.0	.1	.2	.0	93.5	3.4	102.07	74	5
68	.0	.1	.1	.1	.0	91.3	4.0	102.10	91	7
69	1.2	.4	1.1	3.6	.5	49.0	6.2	99.84	453	63
70	.2	.1	.8	.3	.2	76.3	2.6	109.48	483	30
71	.1	.0	.9	.1	.0	92.6	3.3	100.67	50	5
72	.3	.1	2.0	.4	.1	79.8	9.2	97.05	56	10
73	.4	.1	1.7	.4	.1	82.3	6.1	101.00	146	17
74	.6	.3	1.0	4.7	.4	40.3	4.5	109.53	588	57
668										
672										
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Table 2, mode amnts in ppm																		
GEUS-sample#	Cr	Ni	Co	La	Ce	Nd	Ba	Nb	Zr	Y	Sr	Rb	Zn	Cu	Th	Pb	Ga	U
10	415	70	39	42	87	35	316	19	500	20	216	12	72	31	11	6	15	2
11	175	22	46	18	29	13	144	9	362	27	104	12	25	6	6	5	7	3
12	584	42	39	121	249	110	72	39	1838	124	70	7	83	7	41	8	11	4
13	297	42	28	18	32	14	229	8	211	12	179	8	43	16	6	4	9	3
15	849	17	52	31	174	57	bd	183	29244	83	18	0	233	2	32	28	13	15
18	81	21	33	31	50	22	1800	7	358	10	659	44	36	12	9	24	12	2
19	259	32	60	316	581	178	1003	49	5063	40	352	18	84	4	126	16	13	5
20	365	51	41	304	574	200	637	46	6565	68	283	11	121	3	118	14	14	8
25	87	19	50	21	33	15	735	8	335	11	344	20	29	5	7	10	8	2
26	1085	22	84	77	380	156	bd	888	4908	20	58	bd	310	36	149	129	60	15
27	824	21	69	108	588	237	bd	955	8848	27	45	bd	344	41	194	116	42	20
28	647	14	48	180	798	331	bd	789	14388	38	41	bd	270	23	255	95	32	23
29	381	bd	18	2096	7210	3022	bd	387	30752	136	1	bd	237	bd	1661	95	15	95
30	402	6	37	955	4267	1847	bd	594	19344	81	8	bd	221	15	1186	106	19	66
31	56	10	52	34	67	32	286	22	232	16	46	35	39	11	29	11	7	3
33	89	15	23	73	156	71	389	59	383	25	67	40	82	11	60	13	8	6
35	115	18	34	34	66	29	376	19	213	16	45	48	45	12	20	12	8	2
38	142	5	22	329	800	339	bd	168	4431	29	16	bd	45	6	333	31	10	21
39	298	8	34	260	737	313	bd	349	5863	31	9	bd	117	9	272	50	19	18
40	463	10	49	964	3927	1691	bd	569	14156	79	10	bd	222	20	1133	105	26	62
42	79	10	31	48	95	39	429	23	357	11	112	57	28	8	43	18	10	1
45	193	6	46	157	443	176	bd	287	3313	107	181	1	175	10	214	23	11	8
46	201	5	15	952	2877	1193	bd	281	11320	70	310	bd	133	11	941	60	12	47
47	244	8	27	574	1722	718	bd	355	6386	67	264	bd	168	10	589	53	12	28
48	412	6	58	820	3122	1312	bd	577	15612	99	13	bd	341	11	1045	90	25	54
49	124	6	21	27	60	27	26	48	387	32	121	4	52	11	26	6	12	2
50	257	6	37	1937	7253	3059	bd	416	12170	121	2	bd	202	6	2340	103	12	91
52	285	10	34	269	754	326	bd	321	4270	42	67	0	141	18	291	46	19	16
53	102	bd	9	1051	2429	969	86	181	17645	72	346	bd	41	bd	833	39	7	33
54	65	7	23	50	109	46	bd	57	938	7	4	3	16	2	51	4	4	3
55	120	9	44	131	279	117	536	66	567	69	96	72	108	16	129	20	14	5
58	152	7	12	83	174	75	61	119	1882	23	693	9	67	11	67	19	16	4
60	161	9	37	697	2100	844	4	383	8488	39	16	3	175	7	783	41	11	22
61	137	7	22	314	910	362	36	283	5406	43	278	5	136	16	349	23	12	13
62	165	8	46	905	3657	1472	bd	484	13920	50	2	bd	235	10	1270	59	13	36
65	57	8	53	13	22	8	470	29	495	3	86	41	20	7	8	8	8	1
66	67	6	49	30	65	28	1	74	1180	6	6	2	33	8	28	4	4	2
67	60	6	23	26	53	22	4	48	734	6	7	5	16	6	24	2	5	3
68	66	9	29	59	123	54	9	59	1207	9	7	6	21	3	54	5	2	4
69	297	19	61	65	177	72	413	168	2476	94	157	17	179	18	44	12	20	4
70	163	12	39	132	345	132	229	211	3985	17	57	14	120	17	137	9	12	7
71	41	6	20	11	18	7	402	22	521	3	60	21	10	5	9	3	2	1
72	57	17	32	20	40	15	900	13	290	11	155	50	24	12	8	11	7	1
73	84	13	36	36	69	26	765	56	1128	14	128	39	38	12	26	8	9	2
74	319	17	58	218	568	194	185	275	8509	67	147	10	207	12	185	17	16	10
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Table 3, Samples from the Chavara Segment, collected in 2003						
			fraction	fraction	% heavies	
		< 0,045mm	>0,71mm	in fraction<	from	run by
GEUS sam	dian sampl	% of total v	% of total v	>0,045mm	total weigh	CCSEM
2000666	1	0.68	0.72	95.23	93.90	
2000667	1A.	0.57	1.81	89.73	87.60	
2000668	2	0.36	1.09	93.83	92.47	x
2000669	2A.	0.94	8.86	49.21	44.38	
2000670	3	1.22	4.05	75.07	71.11	
2000671	4	0.96	0.78	95.75	94.08	
2000672	5	1.49	0.48	97.89	95.97	x
2000673	5A.	0.33	1.34	76.01	74.74	
2000674	6	1.12	0.51	96.96	95.38	
2000675	6A.	0.42	0.90	84.64	83.52	
2000676	7	0.83	7.43	80.63	73.97	x
2000677	8	1.22	0.18	94.20	92.88	x
2000678	8A	0.14	0.76	69.19	68.57	
2000679	9	0.76	9.91	55.00	49.13	x
2000680	9A	0.52	0.58	93.82	92.79	x
2000681	9B	3.41	7.26	22.30	19.92	x
2000682	9C	4.52	4.05	13.80	12.62	x
2000683	9D	10.15	4.01	11.82	10.15	x
2000684	10	0.62	0.75	93.69	92.41	
2000685	11	0.42	15.74	80.41	67.41	
2000686	11A	0.17	0.73	96.63	95.76	
2000687	12	1.23	0.80	90.30	88.46	
2000688	12A	0.70	1.26	87.54	85.83	
2000689	12B	0.69	7.86	43.03	39.35	
2000690	12C	0.14	22.75	60.37	46.55	
2000691	13	0.38	1.18	84.17	82.86	
2000692	14	0.52	0.61	94.93	93.85	x
2000693	14A	0.74	3.87	48.86	46.61	x
2000694	14B	0.65	3.52	79.67	76.35	x
2000695	14C	0.77	21.40	9.51	7.40	x
2000696	14D	7.50	7.20	12.43	10.60	x
2000697	15	0.09	2.75	75.01	72.88	
2000698	16	0.55	9.14	68.67	62.02	
2000699	16B	2.43	7.22	30.48	27.54	
2000700	17	1.17	3.35	81.43	77.75	
2000701	17A	0.18	7.67	73.03	67.30	
2000702	17B	5.68	4.86	21.60	19.33	
2000703	19	2.18	8.74	45.69	40.70	
2000704	19A	7.18	7.74	24.88	21.17	
2000705	19B	4.60	6.45	17.23	15.33	
2000706	20	0.38	4.13	88.51	84.52	x
2000707	20A	2.94	6.44	12.60	11.42	x
2000708	20B	2.62	11.47	10.53	9.04	x
2000709	20C	7.03	5.60	17.72	15.49	x
2000710	21	0.68	0.90	60.17	59.22	
2000711	18	0.68	0.51	84.72	83.70	
2000712	18A	2.86	8.65	11.08	9.81	
2000713	18B	5.84	12.53	12.58	10.27	
2000714	22	0.64	2.24	76.85	74.63	x
2000715	22A	2.43	3.32	12.90	12.15	x
2000716	22B	2.31	8.68	8.78	7.81	x
2000717	22C	6.72	5.14	10.65	9.38	x
2000718	23	2.18	2.72	13.40	12.75	
2000719	23A	7.49	7.95	12.09	10.22	
2000720	24	0.51	2.00	67.34	65.65	
2000721	24A	0.91	4.11	70.22	66.69	
2000722	25	0.41	3.69	62.22	59.67	
2000723	25A	0.72	0.45	37.29	36.85	
2000724	25B	2.29	4.45	15.02	14.01	
2000725	26	0.50	0.44	43.70	43.29	
2000726	26A	1.52	1.13	77.11	75.07	