

Application of the Zeiss TGA 10 particle-size analyzer in the exploration of stanniferous placers

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Abstract: The Zeiss TGA 10 particle-size analyzer is a suitable analytical tool for the examination of heavy mineral concentrates obtained in stanniferous placer exploration. It can be connected to a stereomicroscope fitted with a drawing apparatus for rapid semi-automatic determination of the particle-size distribution of individual heavy mineral species present. The diameter based on the projected area of a mineral grain to a circle is measured and stored by a microprocessor, and there are facilities for both statistical analysis of the results and for a printout. From these results, the hydraulic equivalence concept may be applied to facilitate the identification of the transportational source of cassiterite. Since the distance of travel of cassiterite from the mineralized bedrock is reflected by the anomalous hydraulic ratios between cassiterite and its associated heavy minerals, these hydraulic ratios will provide useful indications of the lateral and vertical ore grade variation of a stanniferous placer deposit.

INTRODUCTION

The concept of hydraulic equivalence based on Stokes Law was first introduced by Rubey (1933), who examined the controlling factors on the size distribution of heavy minerals within a water laid sandstone. Subsequently, Rittenhouse (1943) used the concept to develop a method of computing hydraulic equivalent sizes, and introduced the term 'hydraulic ratio' which measures directly the relative availability of heavy and light minerals of equivalent hydraulic value. This concept was used by Hazelhoff Roelfzema and Tooms (1969) to assist the interpretation of tin geochemical results of marine sediments off Cornwall. However, hydraulic equivalence applies only to mono-mineralic grains which could not be estimated accurately other than by individual grain measurement (Yim, 1974).

The rapid development of microcomputers in recent years has led to major advancements in the field of image analysis. In this paper, the application of a semi-automatic image analyzer, the TGA 10 particle-size analyzer manufactured by Zeiss (West Germany), to stanniferous placer exploration is outlined. With this analyzer, rapid measurements of the particle-size distribution of individual heavy mineral species for the purpose of applying hydraulic equivalence could be carried out. The main objective is to explore the possibility to use hydraulic ratios between cassiterite and its associated heavy minerals to indicate tin grade variation in a placer.

THE PARTICLE-SIZE ANALYZER

Plate I shows the TGA 10 particle-size analyzer connected to a Zeiss 'SR' model stereomicroscope via a drawing apparatus. The operating controls of the central

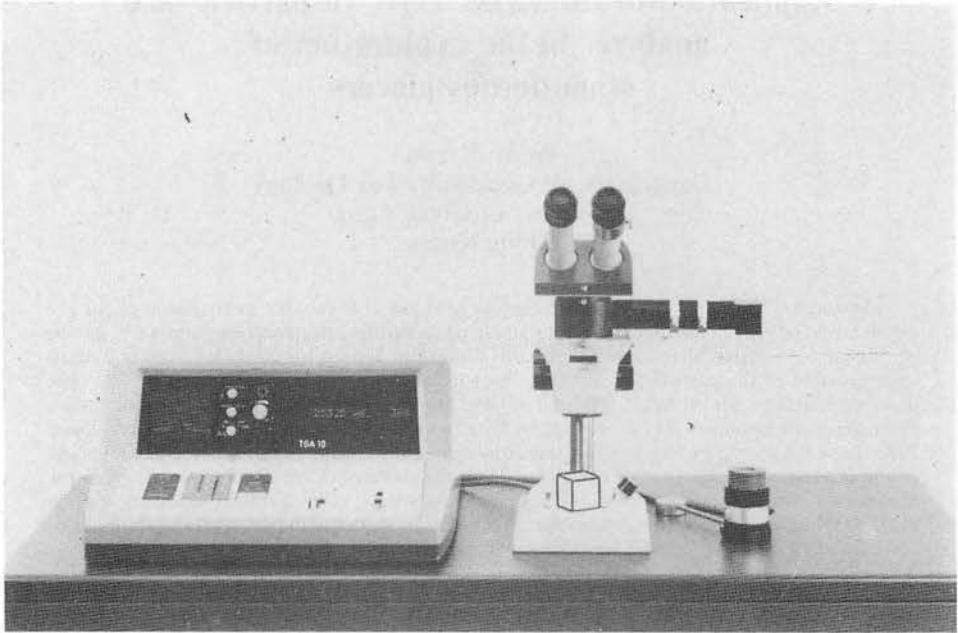
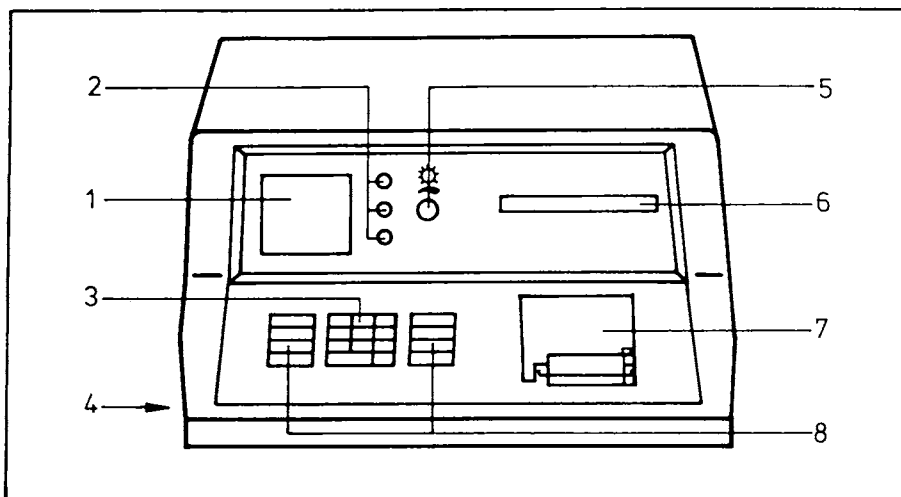


Plate 1. The TGA 10 Particle-size analyzer fitted to a stereomicroscope with drawing apparatus.

processor, and the transducer with accessories are shown in Figs. 1 and 2 respectively. During operation, the image of an iris diaphragm in the transducer is projected into the stereomicroscope, and at the touch of a button, the diameter of the iris diaphragm is transferred into the central processor as a measuring parameter. Mean value, standard deviation and other statistical parameters are calculated automatically from the results of the measurements and documented by the integral printer. When the instrument is equipped with a built-in monitor, histogram or cumulative frequency of the measuring results are plotted during measurement in either linear equidistant (38 classes) or logarithmic equidistant (32 classes) scale. There are programmes available to determine frequencies and cumulative frequencies of the measured diameters; statistical parameters of normal and log-normal distributions such as mean value, standard deviation and range, and, momentum transformation of frequencies and cumulative frequencies and calculation of their statistical parameters.

METHODOLOGY

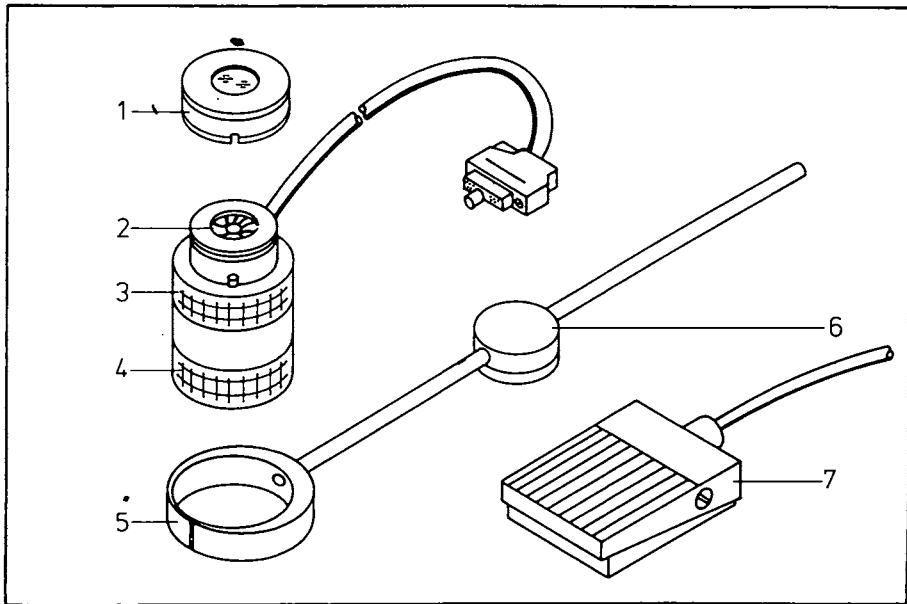
Field samples should preferably be pre-concentrated by panning carefully to avoid the loss of heavy minerals. Tourmaline, which is a common mineral occurring in stanniferous places, could be used to indicate when the panning operation should be terminated. An orientation survey is necessary to determine the most suitable sample spacing to be used. For example, in alluvial excavations where the rock basement is exposed, basal sediment samples should be collected at an interval close enough to pick out sedimentological structures having a significant effect on heavy mineral



- 1 Built-in monitor (option)
- 2 Functional group of 3 switches for built-in monitor
 - X, lin-log : linear or logarithmic scale of abscissa
 - q(X)-Q(X) : histogram of absolute frequency or representation of cumulative frequency
 - Q-q, 10...2000 : ordinate expansion by a factor of 10-100-1000-2000
- 3 Keyboard for input of numbers requested by the display. Every input must be terminated with →
- 4 Power switch
- 5 Brightness control of measuring diaphragm illumination
- 6 Display of measuring results and text
- 7 Integral printer
- 8 Function keys to control measuring and evaluation programs.
The four keys to the left can only be operated when requested by the display. There is generally no displayed instruction for the four keys to the right.

STAT	printout of statistical magnitudes with changed parameters
q	printout of absolute frequency in tabular form or as histogram
Q	printout of cumulative frequency as tabulated numbers
STEREOL	program branch for stereological analysis
→	termination of number input or continuation of program flow
CALC	termination of measuring process and printout of statistical parameters
CL LAST	clearance of last measuring result
RESET	interruption of program flow. Normal continuation of program with <input type="checkbox"/> 0 . Input of <input type="checkbox"/> 1 : complete clearance and system reset.

Fig. 1. Central processor of the TGA Particle-size analyzer.



- 1 Cap with ground glass. Required only to project the measuring diaphragm into a microscope for direct measurement. Plug cap on transducer so that notch and pin are on top of each other.
- 2 Measuring diaphragm
- 3 Knurled ring to adjust the measuring diaphragm
- 4 Transducer with light conductor cable and 14-pin Cannon plug for connection to central processor.
- 5 Transducer holder for one-hand operation for direct measurement in microscopes
- 6 Table support with rubber bottom. To ensure good adhesion clean the rubber bottom regularly with a wet cloth.
- 7 Pedal switch for transfer of measuring results (release) required for direct measurement in microscopes. When used for measurements without microscope it acts parallel with the release key of the projection system.

Fig. 2 Transducer with accessories of the TGA 10 Particle-size analyzer.

distribution, such as channel fill. In the case of boreholes, the samples along the hole should be divided into vertical sections at intervals sufficient to identify important changes in the sediment type.

An example of a sample treatment flow-chart for panned concentrates is shown in Fig. 3. Both heavy liquid and magnetic separations are deemed necessary in the alluvial tin-fields of northeast Tasmania because of the great variety of heavy minerals present (see Table 1). These separations serve the purpose of reducing time spent on mineralogical identification during the grain diameter measurements of each heavy mineral species. The various mineral fractions as shown in Fig. 3 are then mounted

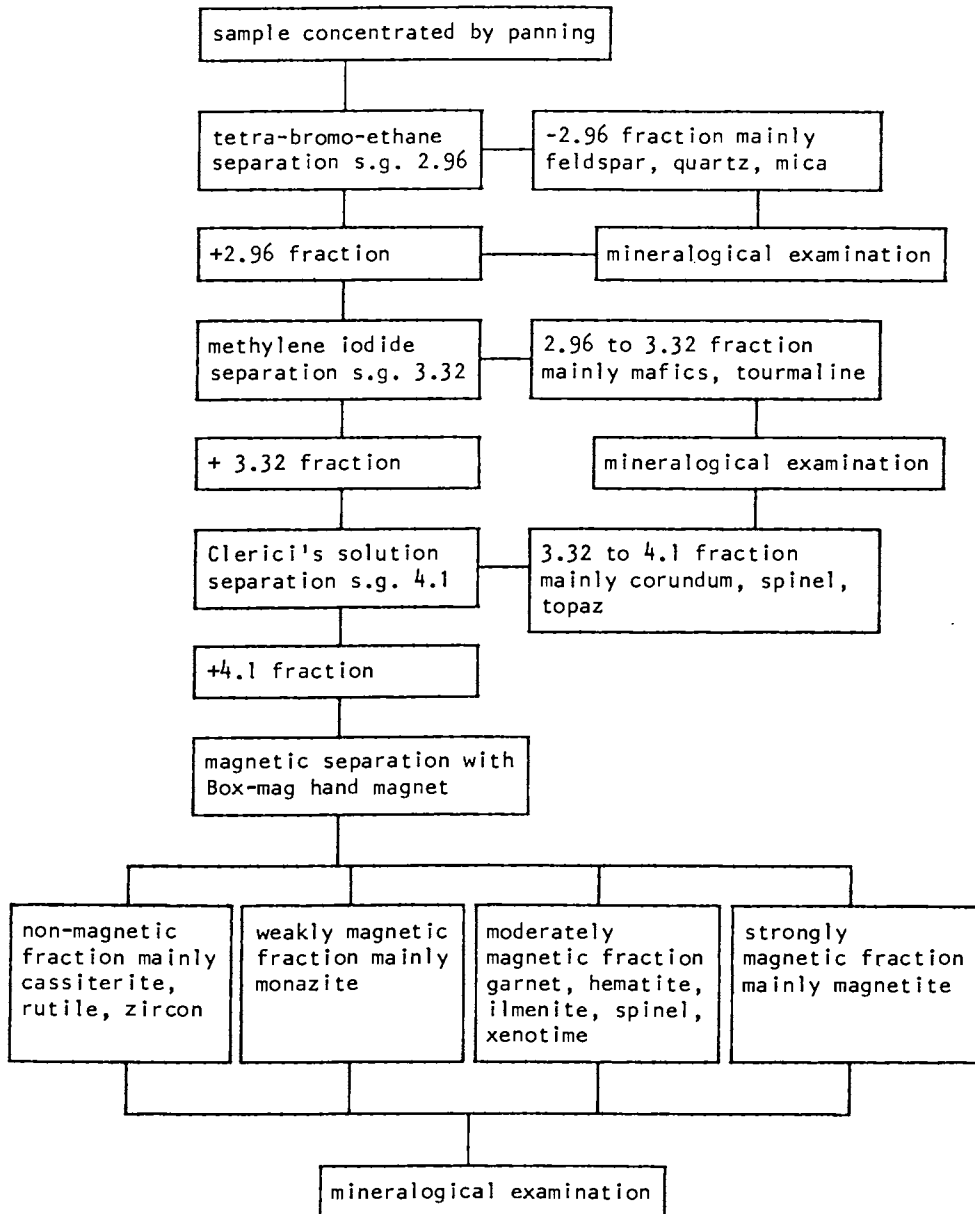


Fig. 3 Flow-chart of sample preparation for stanniferous alluvial samples from northeast Tasmania.

TABLE 1

SUMMARY OF SPECIFIC GRAVITY AND PROVENANCE OF HEAVY MINERALS
FROM THE ALLUVIAL TIN-FIELD OF NORTHEAST TASMANIA

Heavy mineral	S.G.	Probable provenance
Gold	19.3	quartz veins in Mathinna Beds
Cassiterite	7.0	greisens, pegmatites
Scheelite	5.9-6.1	pneumatolytic veins near granite contact with country rock
Magnetite	5.2	mainly from Tertiary basalts
Hematite	5.1	breakdown of ferricrete
Monazite	5.0-5.3	accessory mineral in granitic rocks
Pyrite	5.0	authigenic mineral in sediments
Marcasite	4.9	authigenic mineral in sediments
Chrome-spinel	4.8	ilherzolite inclusions in Tertiary basalts
Ulvospinel	4.8	ilherzolite inclusions in Tertiary basalts
Molybdenite	4.7-4.8	pegmatites
Ilmenite	4.7-4.8	mainly from Tertiary basalts
Zircon -		
fine grain euhedral	4.6-4.7	accessory mineral in granitic rocks
coarse " anhedral	4.6-4.7	megacrysts in Tertiary basalts
Xenotime	4.5	accessory mineral in granitic rocks
Rutile	4.2	rutiliated quartz in pegmatites
Almandine	4.1-4.3	pegmatites, aureoles of thermal metamorphism
Corundum	4.0	megacrysts in Tertiary basalts, aluminium-rich xenoliths
Anatase	3.8-4.0	alteration product of sphene and ilmenite
Pleonaste	3.8-3.9	megacrysts in Tertiary basalts
Limonite	3.6-4.0	breakdown of ferricretes
Topaz	3.6	pegmatites, greisens, aplites
Chrysoberyl	3.5-3.8	pegmatites
Olivine	3.3-3.4	Tertiary basalts including ilherzolite inclusions
Tourmaline	3.0-3.2	schorl veins, pegmatites

separately after thorough mixing on glass slides (76 × 25 mm), using double-sided cellotape prior to their measurement under the stereomicroscope. Each mineral grain is measured by its projected outline to a circle. This is carried out by adjusting the measuring diaphragm of the transducer (Fig. 2). On average, up to over 750 measurements per hour could be made when a pedal switch is used.

RESULTS

An example of a printout of results by the TGA 10 particle-size analyzer is shown in Table 2. If it is required, a listing of each of the measurements could also be obtained from the integral printer.

In a case study of the alluvial tin-field of northeast Tasmania, cassiterite was invariably found to be associated with topaz (Yim, 1980). In addition, the great abundance of topaz makes it a suitable mineral for applying the hydraulic equivalence concept. Preliminary results show that the ratio between the arithmetic mean diameter values of cassiterite and topaz reflected their respective mobility which is governed primarily by differences in their specific gravities. The high specific gravity of cassiterite

TABLE 2
PRINTOUT OF RESULTS FROM THE TGA 10 PARTICLE-SIZE ANALYZER

No. of measurement	n	162
Arithmetic mean	x	128.6 μm
Standard deviation	S	6.683 μm
16 per cent passing	X16	121.9 μm
84 per cent passing	X84	135.3 μm
Minimum result	MIN	111.2 μm
Maximum result	MAX	146.3 μm
Difference	MAX-MIN	35.16 μm

(7.0) in addition to its brittleness makes it appreciably less mobile in comparison to topaz would indicate closeness to the source of cassiterite mineralized bedrock, or in other words to where a richer ore grade is expected. On the other hand, a small hydraulic ratio caused by the abundance of topaz may be used as a dispersion halo for identifying locations of cassiterite enrichment during prospecting. At increasing distances away from the mineralized bedrock, both cassiterite and topaz will be expected to decrease in grain size, but the pattern of decrease would be related to their relative mobility during reworking.

CONCLUSION

Although only preliminary results are presented here, the application of the TGA 10 particle-size analyzer shows promise in stanniferous placer exploration and warrants further research work. It is an analytical tool for applying hydraulic equivalence as well as for testing the application of the concept. In new areas to be tested, it is necessary to determine the provenance of heavy minerals beforehand in order that suitable associated heavy minerals with cassiterite may be chosen to determine hydraulic ratios.

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