Asterism in Sri Lankan corundum

Autor(en): **Sahama, Th.G.**

Objekttyp: **Article**

Zeitschrift: **Schweizerische mineralogische und petrographische Mitteilungen = Bulletin suisse de minéralogie et pétrographie**

Band (Jahr): **62 (1982)**

Heft 1

PDF erstellt am: **26.09.2024**

Persistenter Link: https://doi.org/10.5169/seals-47959

Nutzungsbedingungen

Die ETH-Bibliothek ist Anbieterin der digitalisierten Zeitschriften. Sie besitzt keine Urheberrechte an den Inhalten der Zeitschriften. Die Rechte liegen in der Regel bei den Herausgebern.
Die auf der Plattform e-periodica veröffentlichten Dokumente stehen für nicht-kommerzielle Zwecke in Lehre und Forschung sowie für die private Nutzung frei zur Verfügung. Einzelne Dateien oder Ausdrucke aus diesem Angebot können zusammen mit diesen Nutzungsbedingungen und den korrekten Herkunftsbezeichnungen weitergegeben werden.
Das Veröffentlichen von Bildern in Print- und Online-Publikationen ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Die systematische Speicherung von Teilen des elektronischen Angebots auf anderen Servern bedarf ebenfalls des schriftlichen Einverständnisses der Rechteinhaber.

Haftungsausschluss

Alle Angaben erfolgen ohne Gewähr für Vollständigkeit oder Richtigkeit. Es wird keine Haftung übernommen für Schäden durch die Verwendung von Informationen aus diesem Online-Angebot oder durch das Fehlen von Informationen. Dies gilt auch für Inhalte Dritter, die über dieses Angebot zugänglich sind.

Ein Dienst der *ETH-Bibliothek*
ETH Zürich, Rämistrasse 101, 8092 Zürich, Schweiz, www.library.ethz.ch

http://www.e-periodica.ch

Schweiz. mineral. petrogr. Mitt. 62, 15–20, 1982

Asterism in Sri Lankan corundum

by *Th. G. Sahama* *

Abstract

This paper describes the identification and crystallographic orientation of the rutile inclusions found in a corundum from the Elahera area, Sri Lanka.

The corundum crystals are heavily zoned (fig. 1). The rutile inclusions are almost invariably twinned either of a needle-like habit with two individuals or geniculated with three or four individuals. The twin plane is {011} and the needle axis is $\langle 01\bar{1} \rangle$. The orientation of the rutile inclusions in the corundum host is the following:

$$\text{Rutile } \langle 010 \rangle \parallel \text{Corundum } [0001]$$
$$\text{Rutile } \langle 01\bar{1} \rangle \parallel \text{Corundum } \langle 11\bar{2}0 \rangle$$

INTRODUCTION

The asterism found in some Sri Lankan corundum cabochons (star sapphires) has been known from antiquity. This optical effect is caused by a regular arrangement of needle-like inclusions in the corundum host. It was eminently illustrated by GÜBELIN (1974) and was recently optically explained by WEIBEL et al. (1980) and by WÜTHRICH and WEIBEL (1981).

GUSTAV TSCHERMAK was probably first to suggest already in 1878 that the needles consist of rutile. Their identification and crystallographic orientation was later studied with modern methods by a number of authors. A review of the literature concerned is contained in the paper by PHILLIPS et al. (1980).

The solution of the problem has been seriously hampered by the extremely small size of the needles in the asteriated Sri Lankan corundum. Therefore, the most recent studies used synthetic titanium-doped corundum crystals in which the needles could be grown large enough for optical microscopy and X-ray etc. work (TAKUBO et al., 1978; PHILLIPS et al., 1980).

In 1972 the author was able to obtain some specimens of corundum from a local miner in the Elahera area in Sri Lanka. The exact provenance is not

* Dept. of Geology, Snellmanink. 5, SF-00170 Helsinki, Finland.

known to the author. These corundum crystals were found to contain needle-like, slightly bladed inclusions, up to 1 x 0.05 x 0.002 mm in size with the shortest dimension subparallel to the corundum c-axis. They thus allow an optical microscopic and microprobe study. Because such studies on natural Sri Lankan crystals are not available in the literature, the results obtained will be reported in this paper.

MATERIAL

The Elahera corundum crystals available for this study are slightly bluish and turbid, subhedral to euhedral of a barrel shaped habit. They are up to 7 cm long and show a well developed rhombohedral parting with boehmite in the seams. The mineral is constantly associated with a blue spinel (table 1), black in hand specimen, which invades the corundum and replaces its crystal margins. The specimens contain also small amounts of partly chloritized brown mica (phlogopite), graphite and bluish apatite. A few tiny euhedral rutile and diaspore prisms could be detected in the interstices between the large corundum crystals. Some interstitial powdery anatase is probably an alteration product of rutile.

Table 1 Blue spinel invading corundum, Elahera area. Composition and physical data. Microprobe analysis by Kirsti Hämäläinen. FeO: total iron.

	Wt. %	O = 32		Molecular composition	
SiO_2	0.34	Si	0.07	Al_2MgO_4	82.2 %
Al_2O_3	67.3	Al	15.73	Al_2FeO_4	16.2
FeO	10.1	Fe	1.68	Fe_3O_4	1.5
MnO	0.15	Mn	0.03		
MgO	22.2	Mg	6.56		
TiO_2	trace				
CaO	trace				
Total	100.09				

n = 1.735 ± 0.002

Density = 3.72 ± 0.02 (Berman balance)

a = 8.105 ± 0.003 Å

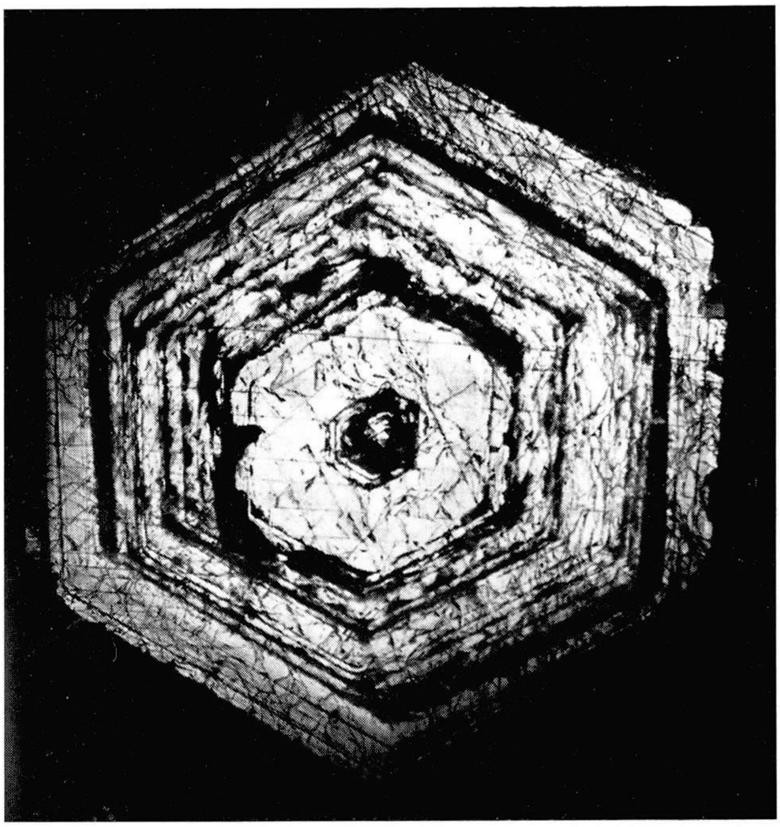

Fig. 1 Zoned corundum crystal, section approximately perpendicular to the c-axis. Zones containing abundant inclusions (white) alternate with those free from inclusions (black). Diameter of the crystal 2.5 cm. Elahera area, Sri Lanka.

The corundum is invariably heavily zoned. The zoning is not caused by coloring but by an alternation of zones entirely free from the needles with those in which the needles are very abundant. The zone boundaries are sharp. In sections cut perpendicular to the corundum c-axis the needle-rich zones display a bright chatoyancy while the needle-free zones remain extinguished (Fig. 1).

IDENTIFICATION OF RUTILE

Fig. 2 illustrates scanning electron microscope images of a needle-like inclusion in the corundum matrix. The inclusion shows high Ti, extremely faint Fe and no Al, Si and Ca (Fe, Si and Ca not reproduced in the figure). The needles are highly birefringent. They are almost invariably twinned, either two individuals with the twin plane parallel to the elongation axis or geniculated with three or four individuals. The angle between the extinction direction (c-axis) and the elongation axis of the needle is nearly 57°.

Allowing for the necessary uncertainty in extinction angle measurements, this value agrees with the angle between the c-axis and the common twin plane

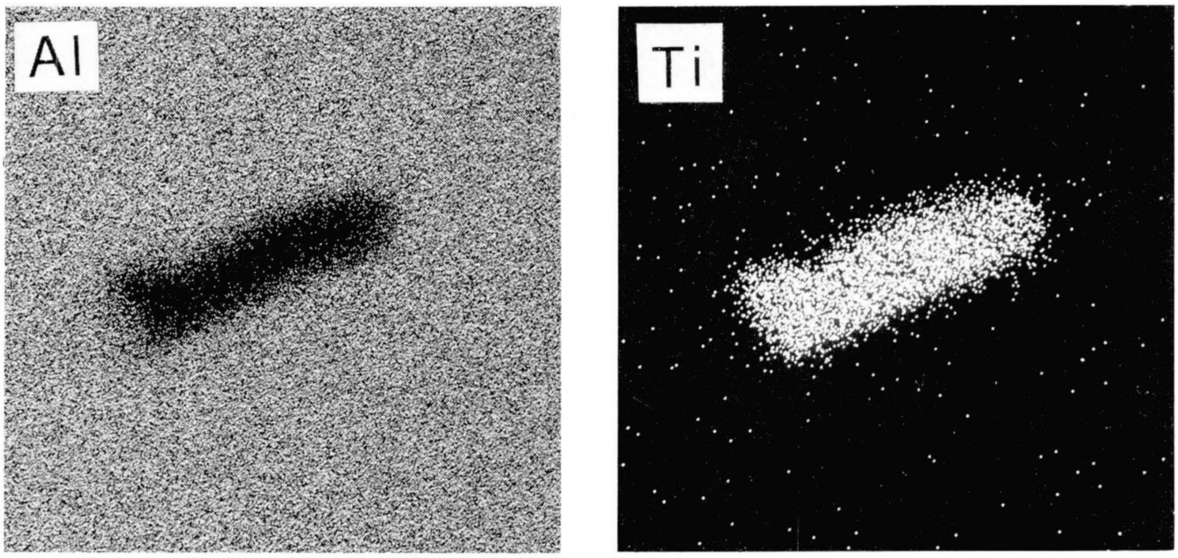

Fig. 2 Scanning electron microscope images of a rutile inclusion in corundum matrix. Length of the rutile needle 7 microns. Elahera area, Sri Lanka.

{011} of rutile, i.e. 57.2°, calculable from the unit cell dimensions of the mineral. These data prove the inclusions to be rutile and exclude anatase and brookite.

NEEDLE ORIENTATION

Fig. 3 illustrates schematically the orientation of the rutile inclusions in the corundum host. The indices of the corundum prism faces in this figure were checked with a zero layer X-ray precession photograph about the c-axis. The elongation axis of the rutile needles is not the crystallographic c-axis but $\langle 01\bar{1} \rangle$. This needle axis is parallel to $\langle 11\bar{2}0 \rangle$ of corundum (Weber symbols: McKie and McKie, 1974, pp. 69–71). The zone axis $\langle 010 \rangle$ of rutile is parallel to the c-axis of corundum. Such an orientation implies that the optical extinction directions of the rutile inclusions deviate 2.8° from the directions of the hexagonal outlines of the corundum crystal. This deviation was microscopically confirmed.

Compared with the previous data, the following summary presents the orientation of the rutile needles in the corundum host:

	Rutile		Corundum
Takubo et al. (1978)	(100)	~||	(0001)
(synthetic)	$\langle 001 \rangle$	||	$\langle 10\bar{1}0 \rangle$
Phillips et al. (1980)	{100}	||	{0001}
(synthetic)	{011}	||	$\{1\bar{2}10\}$
	$\langle 01\bar{1}1 \rangle$	||	$\langle 10\bar{1}0 \rangle$
This paper	$\langle 010 \rangle$	||	[0001]
(natural)	$\langle 01\bar{1} \rangle$	||	$\langle 11\bar{2}0 \rangle$

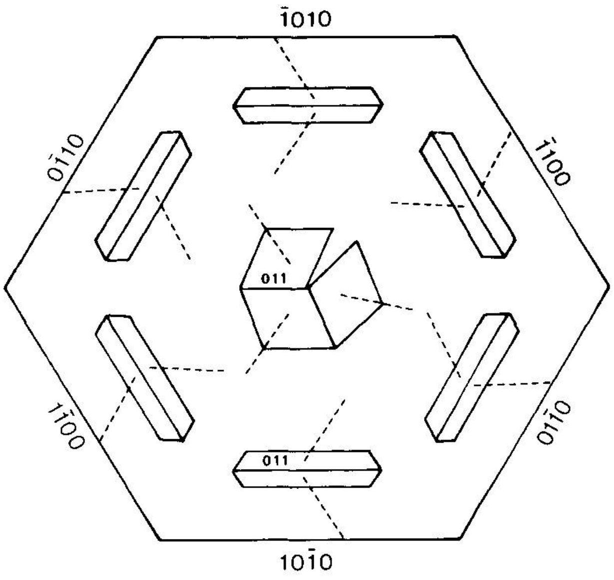

Fig. 3 Section parallel to (0001) across an Elahera corundum crystal illustrating schematically the orientation of the needle-like and geniculated rutile twins on (011). Broken lines indicate the traces of the c-axes in the rutile individuals.

ORIGIN OF RUTILE INCLUSIONS

The origin of the rutile inclusions in corundum can not be interpreted on the basis of experimental evidence. The phase equilibria in the dry system Al_2O_3-TiO_2 (LANG et al., 1952) are known only in a temperature range well above the temperatures which can be considered reasonable of the corundum crystallization in the Elahera area. In hydrothermal environment the system is unexplored. It is commonly assumed that the rutile phase originates through exsolution from a homogeneous corundum phase with TiO_2 in solid solution. This assumption is based on the mode of occurrence of rutile in the corundum host which is typical of an exsolution. On the other hand, a joint crystallization of corundum and rutile in regular arrangement can, so far, not be entirely excluded. Such an interpretation is suggested, but not proved, by the zoned structure found in corundum crystals (Fig. 1). Microprobe determination of titanium in the corundum phase both in the rutile-free and rutile-bearing zones yielded the same values, i.e. ca. 0.1 wt% TiO_2 or less. In the processes of exsolution and simultaneous crystallization the mutual orientation of the corundum and rutile phases could be expected to be identical.

Acknowledgments

The author is indebted to Mrs. Kirsti Hämäläinen, of the Outokumpu Mining Co., for the microprobe analysis of the spinel and to Mr. Ragnar Törnroos, of the Geological Survey of Finland, for the microprobe tests of titanium in the corundum phase.

References

GÜBELIN, E., (1974): Internal World of Gemstones. ABC Edition, Zürich.
LANG, S. M., FILLMORE C. L. and MAXWELL, L. H. (1952): J. Res. U.S. Nat. Bur. Stand, 48, 298-318.
MCKIE, D. and MCKIE, CH. (1974): Crystalline Solids. Thomas Nelson and Sons Ltd, London.
PHILLIPS, D. S., HEUER, A. H. and MITCHELL, T. E. (1980): Precipitation in star sapphire. I. Identification of the precipitate. Philos. Mag. 42, 3, 385-404.
TAKUBO, H., KITAMURA, Y., KUME, SH. and KOIZUMI, M. (1978): Preparation of star-ruby containing large crystal of rutile. XI General Meeting of IMA, Abstracts, III, 52.
WEIBEL, M., WESSICKEN, R., WOENSDREGT, C. F. und WÜTHRICH, A. (1980): Sternsaphir und Sternquarz. Schweiz. mineral. petrogr. Mitt. 60, 133-136.
WÜTHRICH, A. and WEIBEL, M. (1981): Optical theory of asterism. Phys. Chem. Minerals 7, 53-54.

Manuscript received January 17, 1982