

Note: This is a special corrected Table of Contents and Errata sheet, current through 25 February 2018

# CONTENTS

<b>Something of Myself</b> .....	<b>35</b>	Section 1: The perception of color	109
<b>Author's notes</b> .....	<b>42</b>	Section 2: Trace element analysis	111
Notes on methodology	42	Section 3: Trace element interactions	112
Special thanks	44	Section 4: Absorption & transmission of light by a gemstone	116
Authorship	44	Section 5: Chromophores of natural corundum & their colors	120
Fact checking	44	Comparing chromophores	136
Our Staff	44	Section 6: Mixed chromophores & their colors	136
Other help	44	Visible absorption spectra with the hand spectroscope	140
<b>Acknowledgments</b> .....	<b>44</b>	Non-visible spectra	141
Libraries	46	Luminescence	151
In memoriam	46	Pleochroism	158
John Emmett sends thanks to...	46	Bibliography	161
Kenneth Scarratt sends thanks to...	46	<b>Under the Magnifying Glass:</b>	
A final thanks	46	<b>Inclusions</b> .....	<b>167</b>
<b>History</b> .....	<b>51</b>	History of inclusion research	167
History	52	The microscope—A gemologist's best friend	168
Ruby & sapphire in ancient China	54	Photomicrography	169
Ruby & sapphire in ancient India	54	Mastering the microscope—Illumination techniques	169
Arabic-script mineralogy	55	Inclusion types & formation	173
Europe in the Dark & Middle Ages—Under the yoke of the church	60	Pre-existing inclusions (protogenetic)	173
Marco Polo, Gutenberg and the reawakening of Europe	63	Contemporary inclusions (syngenetic)	173
Final unification of ruby & sapphire	68	Secondary inclusions (epigenetic)	178
Bibliography	71	Identifying solid inclusions	183
<b>Chemistry &amp; Crystallography</b> .....	<b>77</b>	Describing inclusions	185
Chemical composition	77	Overview of corundum inclusions	185
The corundum structure	77	Country descriptions of inclusions	185
Crystallography of corundum	80	Lab origin reports	185
Twinning in corundum	82	Bibliography	192
Morphology (face probability) & habit	84	<b>Treatments</b> .....	<b>197</b>
Ruby habits	85	History of ruby & sapphire treatments	197
Sapphire habits	86	Modern heat treatment—Low temperature	200
Bibliography	88	Modern heat treatment—High temperature	201
<b>Physical &amp; Optical Properties &amp; Phenomena</b> .....	<b>93</b>	High temperature heat treatment processes	204
Cleavage, parting & fracture	93	Diffusion & diffusion-like processes	210
Hardness	94	Detection of heat treatment	220
Thermal properties	95	Cavity & fissure infilling	230
Melting & boiling points & solubilities	95	Irradiation	233
Density & specific gravity	96	Oil, dye & wax treatments	237
Electrical properties	96	Surface coatings & surface stains	239
Optical properties	96	Bibliography	239
Luster	99	Disclosure: A revolution rebottles the treatment genie	240
Optical phenomena	99	<b>Synthetic Corundum</b> .....	<b>249</b>
Other phenomena	104	Alchemists' dreams	249
Bibliography	104	Enter Verneuil	251
<b>Color, Spectra &amp; Luminescence</b> .....	<b>107</b>	Verneuil's discovery	255
Introduction to color	107	A close look at Verneuil's process	256
Color in ruby & sapphire	107	Identifying features	262
		Verneuil visible absorption spectra	266

Synthetic star corundum	266	Rock types	404
Czochralski (pulling) process	273	Corundum & corundum gems	404
Floating zone process	275	Born of fire: Corundum in igneous rocks	406
Combination melt techniques	276	Ch-Ch-Changes: Metamorphic rocks	407
“Recrystallized” ruby	276	Corundum-bearing orogenic belts	408
Solution growth processes	278	Case studies of gem corundum formation	408
Summary of flux identification	298	Rock & roll: Secondary deposits	417
Advanced identification techniques	298	Further reading	420
Bibliography	300	Summary of world corundum occurrences	420
<b>Assembled Stones</b> . . . . .	<b>311</b>	Bibliography	420
Coatings	314	<b>World Sources</b> . . . . .	<b>431</b>
Foilbacks & mirrorbacks	314	<b>Afghanistan</b> . . . . .	<b>431</b>
Assembled rough	315	Jegdalek	431
Assembled stars	315	Other Afghan sources	432
Identification of assembled stones	315	Characteristics of Afghanistan ruby (Jegdalek)	432
Bibliography	316	<b>Australia</b> . . . . .	<b>438</b>
<b>Methods of Fashioning</b> . . . . .	<b>319</b>	History of Australian sapphire	438
Cutting basics	319	Mining methods	440
Preforming & orientation	320	Stone types & sizes	444
Cutting styles	327	Marketing of Australian corundum	445
Cabochons	329	Ruby in Australia	446
Carved & engraved rubies & sapphires	330	Characteristics of Australian (NSW & Anakie) corundum	446
Bibliography	330	<b>Bolivia</b> . . . . .	<b>450</b>
<b>Judging Quality:</b>		<b>Brazil</b> . . . . .	<b>450</b>
<b>A Connoisseur’s Guide</b> . . . . .	<b>333</b>	Characteristics of Indaiá (Brazil) corundum	450
Ruby & sapphire grading: A heretic’s guide	333	<b>Burundi</b> . . . . .	<b>450</b>
A brief history of colored stone grading	334	<b>Cambodia—see Thailand/Cambodia</b> . . . . .	<b>450</b>
The elements of quality	337	<b>Cameroon</b> . . . . .	<b>450</b>
Influence of lighting on color	341	<b>Canada</b> . . . . .	<b>451</b>
Viewing geometry & background	342	<b>China</b> . . . . .	<b>452</b>
Summary of quality	343	Corundum in China	454
Pricing factors	343	Other Chinese localities	456
Connoisseurship in ruby	345	<b>Colombia</b> . . . . .	<b>457</b>
Connoisseurship in sapphire	346	Characteristics of Colombia sapphire	457
Fancy sapphires	348	<b>Congo (Democratic Republic of)</b> . . . . .	<b>457</b>
Judging stars & cabochons	349	<b>Czech Republic</b> . . . . .	<b>458</b>
Trapiche ruby & sapphire	350	<b>Finland</b> . . . . .	<b>458</b>
Anatomy of the perfect ruby & sapphire	350	<b>France</b> . . . . .	<b>459</b>
Market tastes	350	<b>Germany</b> . . . . .	<b>460</b>
Lotus Gemology Ruby & Sapphire Color Types	352	<b>Greece</b> . . . . .	<b>460</b>
Lotus Gemology Ruby & Sapphire Color Types	353	<b>Greenland</b> . . . . .	<b>461</b>
Buying ruby & sapphire	358	<b>India</b> . . . . .	<b>463</b>
Rubies & sapphires of note	358	Kashmir sapphires—blue velvet	463
Rubies described by Tavernier	359	History of the Kashmir mine	464
A handful of historic rubies	359	Kashmir sapphires compared	472
Star rubies of note	361	Characteristics of Kashmir sapphire	474
Rough rubies of note	361	Other corundum localities in India	478
Notable red spinels	361	Indian ruby	478
Rubies, spinels & sapphires in the Mughal treasury	366	<b>Italy</b> . . . . .	<b>482</b>
Famous blue sapphires	367	<b>Japan</b> . . . . .	<b>483</b>
Famous fancy sapphires	370	<b>Kenya</b> . . . . .	<b>483</b>
Engraved & carved rubies and sapphires	370	Two geologists’ dream: Their own ruby mine	483
Bibliography	395	Characteristics of Mangari ruby	484
<b>Geology</b> . . . . .	<b>403</b>	Baringo	486
Elemental mating game	403	Other Kenya ruby localities	486
The big bang	403		
Journey to the center of the earth	403		
Tales from the crust	403		

## CONTENTS

Sapphire in Kenya	486	Characteristics of Sri Lankan corundum	597
<b>Israel</b> .....	<b>488</b>	<b>Sweden</b> .....	<b>609</b>
<b>Laos</b> .....	<b>488</b>	<b>Switzerland</b> .....	<b>609</b>
<b>Liberia</b> .....	<b>491</b>	<b>Tajikistan</b> .....	<b>610</b>
<b>Macedonia</b> .....	<b>491</b>	Kuh-i-Lal spinel mines	610
<b>Madagascar</b> .....	<b>491</b>	Kukurt/Snezhny ruby mines	615
Island at the end of the universe	491	<b>Tanzania</b> .....	<b>620</b>
Andranondambo	493	The Mozambique orogenic belt—East Africa’s cauldron of gem creation	620
Ilakaka	494	Localities	621
Andilamena region	494	<b>Thailand/Cambodia</b> .....	<b>636</b>
Didy	496	History	636
Ambodivoahangy (Zahamena National Park)	496	Mining areas	642
Vatomandry	497	Chanthaburi, Trat & Pailin deposits	642
Ambohimandroso	497	Mining methods	651
The far north	497	Characteristics of Thai/Cambodian ruby	656
<b>Malawi</b> .....	<b>508</b>	Characteristics of Thai/Cambodian sapphire	662
<b>Mexico</b> .....	<b>511</b>	<b>Turkey</b> .....	<b>675</b>
<b>Mozambique</b> .....	<b>512</b>	<b>Uganda</b> .....	<b>675</b>
<b>Myanmar (Burma)</b> .....	<b>520</b>	<b>United Kingdom (UK) &amp; Ireland</b> .....	<b>675</b>
History	520	<b>United States of America (USA)</b> .....	<b>676</b>
Myanmar today	539	Idaho	676
Mining areas	540	Montana	677
Burmese sapphires	540	Yogo Gulch	678
Other gems from the Mogok area	541	Other Montana corundum localities	682
Mining methods	541	Characteristics of Montana corundum	687
Sorting & trading	546	North Carolina	695
Burmese rubies compared	546	<b>Vietnam</b> .....	<b>696</b>
Burmese sapphires compared	547	Enter Doi Moi	696
Other Myanmar corundum localities	548	History	696
Features of Mogok (Myanmar) corundum	553	Luc Yen	697
Future prospects for Myanmar	560	Quy Chau (Bu Khang District)	698
<b>Namibia (Southwest Africa)</b> .....	<b>575</b>	Other Vietnam corundum localities	702
<b>Nepal</b> .....	<b>576</b>	Mining methods in Vietnam	702
Mountain building	576	Characteristics of Vietnamese corundum	703
<b>New Zealand</b> .....	<b>576</b>	<b>Zimbabwe</b> .....	<b>707</b>
<b>Nigeria</b> .....	<b>577</b>	<b>Tagore’s Ruby &amp; Sapphire</b> .....	<b>709</b>
Characteristics of Nigerian sapphire	577	<b>Prices &amp; ID flow charts</b> .....	<b>715</b>
<b>Norway</b> .....	<b>577</b>	Market Notes—2016	715
<b>Pakistan</b> .....	<b>580</b>	Ruby	715
Hunza: Land of the “Great Game” and eternal life	580	Blue sapphire	715
Azad Kashmir	580	Fancy sapphires	716
Other Pakistan localities	581	Star stones & cabochons	717
<b>Russia</b> .....	<b>582</b>	Buying/Selling/Appraising	717
<b>Rwanda</b> .....	<b>583</b>	Lab reports	717
Sapphires in the mist	583	Price tables	717
<b>Sierra Leone</b> .....	<b>583</b>	Category notes	717
<b>Somalia</b> .....	<b>583</b>	Identification flow charts	720
<b>South Africa</b> .....	<b>585</b>		
<b>Sri Lanka (Ceylon)</b> .....	<b>586</b>		
Ratna Dweepa—The Island of Jewels	586		
History	586		
Ruby & sapphire varieties	593		
Origin of Sri Lanka’s corundum deposits	593		
Mining areas	594		
Mining methods—It’s the pits	594		
The market in Sri Lanka	597		

## ERRATA

### PAGE 2

#### Spill the wine

Important pair of ruby and diamond pendent earrings, featuring untreated Mozambique Myanmar rubies of 11.10 and 10.41 ct respectively. These sold for HK\$8,850,000 (US\$1,141,223) at Tiancheng's 15 December 2015 sale. Image © Tiancheng International Auctioneer Ltd.

### PAGE 46

#### Column 2, paragraph 8

Change Zylin Sun to Ziyin Sun.

### PAGE 65

#### Column 2, last paragraph

Change 18 cm to 18 mm.

### PAGE 94

#### Column 1, last paragraph

Change cohesion to adhesion

### PAGE 161

#### Column 2, add:

Chase, A.B. and Osmer, J.A. (1970) Habit changes of sapphire grown from PbO-PbF<sub>2</sub> and MoO<sub>3</sub>-PbF<sub>2</sub> fluxes. *Journal of the American Ceramic Society*, Vol. 53, No. 6, pp. 343–345; RWHL.

### PAGE 162

#### Column 1, add:

Harlow, George E. and Bender, W. (2013) A study of ruby (corundum) compositions from the Mogok Belt, Myanmar: Searching for chemical fingerprints. *American Mineralogist*, Vol. 98, No. 7, pp. 1120–1132.

### PAGE 258

#### Column 2, Figure 7.13, line 2

change "In natural stones (right)..." to "In natural stones (left)..."

### PAGE 264

#### Column 2, Table 7.2, Verneuil Syn. Corundum, Red, Pink

change "C<sup>3+</sup>" to "Cr<sup>3+</sup>".

### PAGE 326

#### Figure 9.10

change "γ" to "α".

### PAGE 549

Figure 12.45. Map. Change "Andrandondambo" to "Andranondambo".

### PAGE 549

Figure 12.99. Superb example of a 15 ct untreated Mōng Hsu Mogok ruby.

Photo: Wimon Manorotkul; ring: Veerasak Gems

### PAGE 725

#### Column 2

Add Galibert, Olivier 45, 389, 454–456, 527–528, 571, 656