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Synthetic emeralds

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Scope of presentation

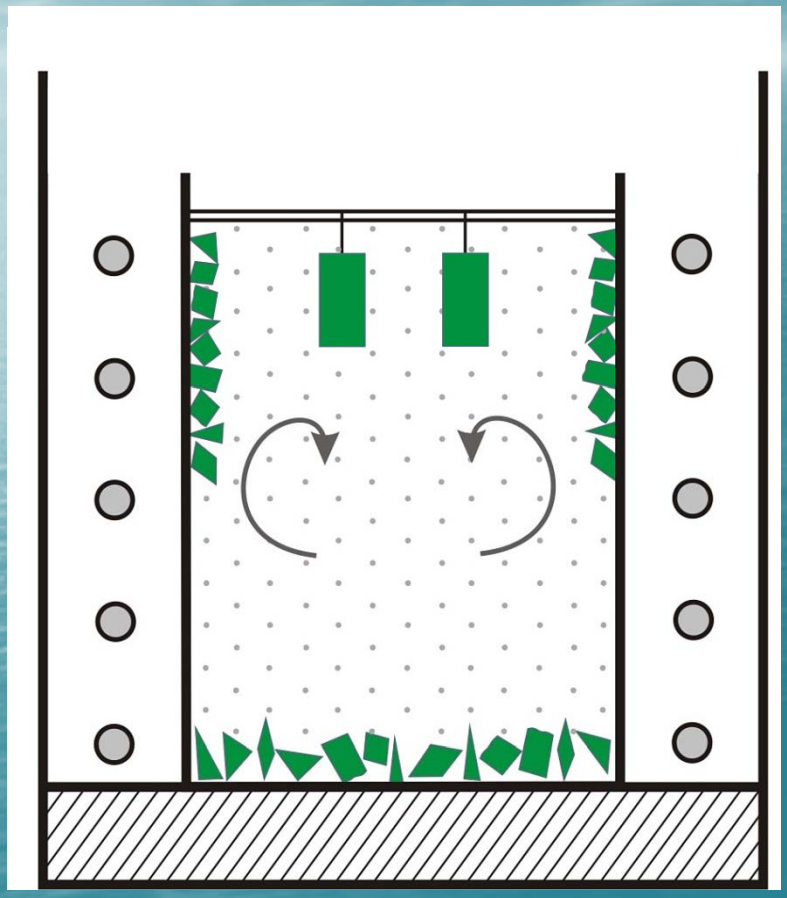
- Synthetic emeralds producers
- Methods of emerald synthesis
- Main features of synthetic emeralds
- Microworld and inclusions
- Visible absorption spectra
- Infrared spectra
- Trace element chemistry
- Market of synthetic emeralds

Synthetic emeralds producers

- First efforts made in France in XIX century
- C. Chatham (US) about 1940
- P. Gilson (France) about 1960
- Linde, about 1970
- Kyocera (Japan), before 1980
- Biron (Australia) about 1980
- USSR (Russia) about 1985
- Tairus (Thailand/Russia) about 1990
- Malossi (Italy/Chech) 2004

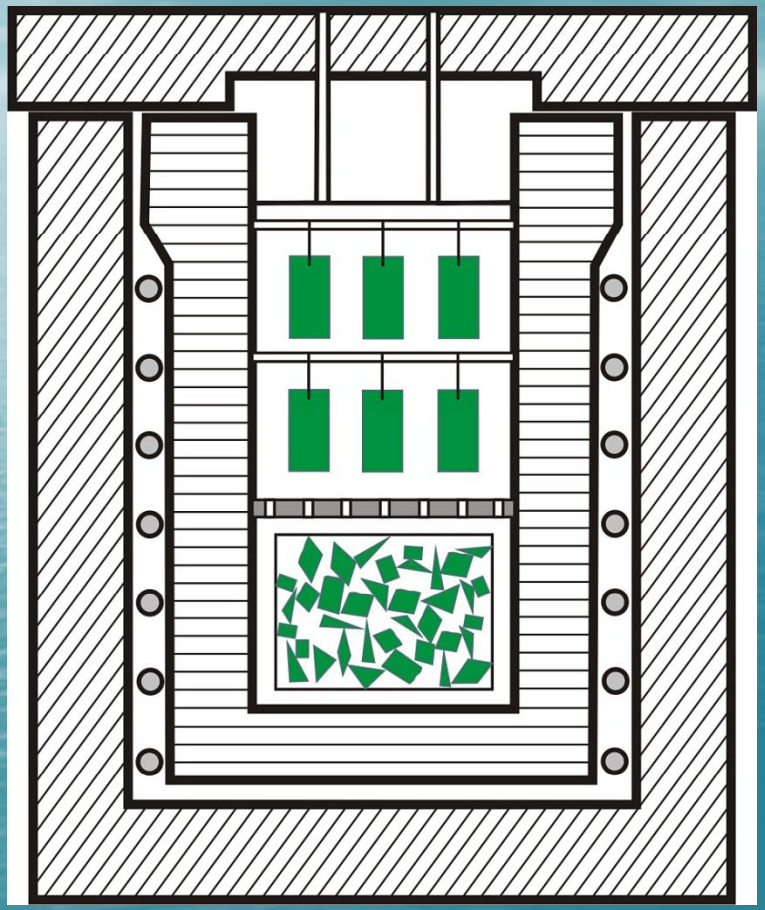
All use one of two growth methods: “flux” or “hydrothermal”

Flux method



Flux grown emeralds do not contain water

Hydrothermal method

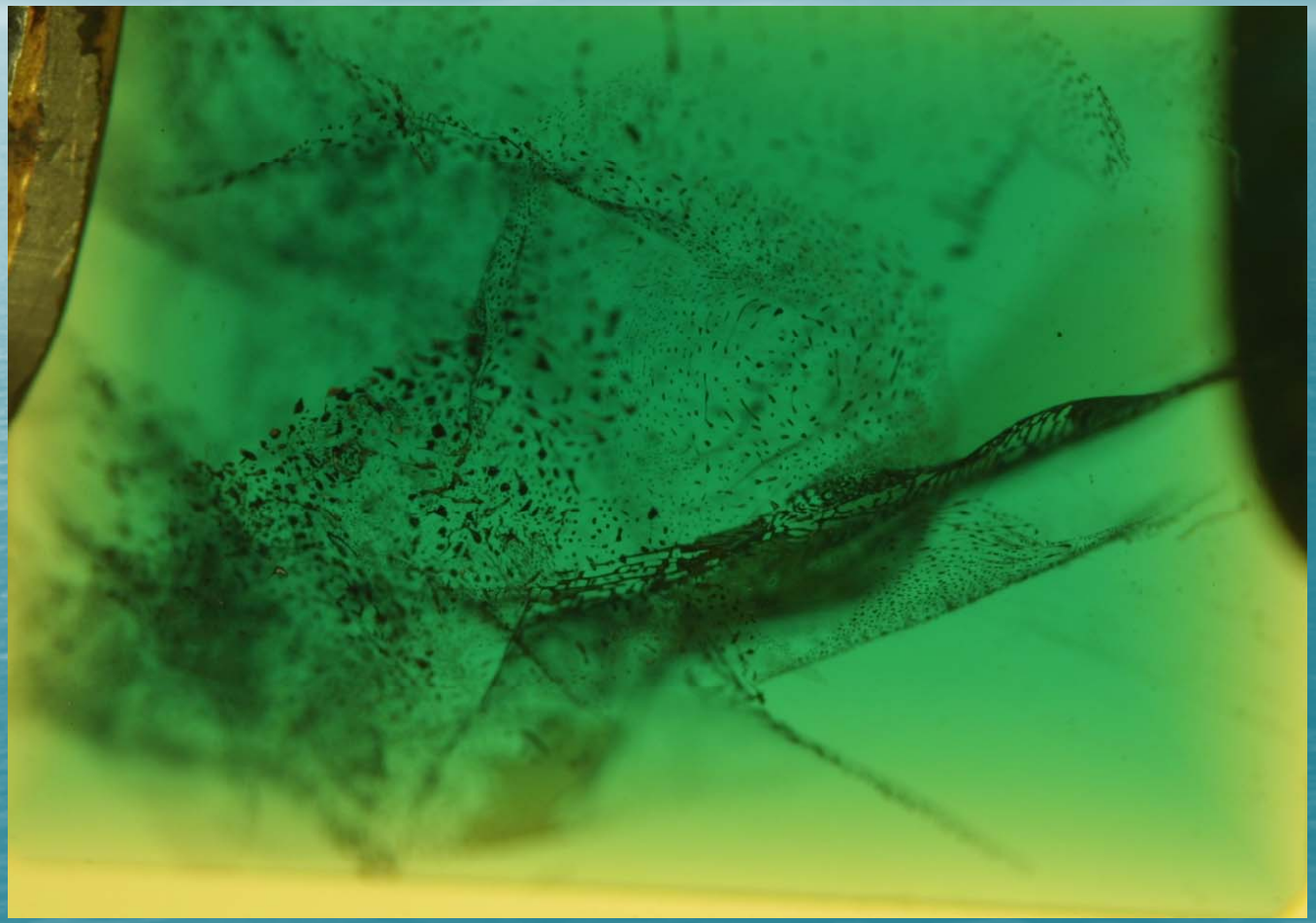


An autoclave for hydrothermal synthesis and resulting emerald crystal

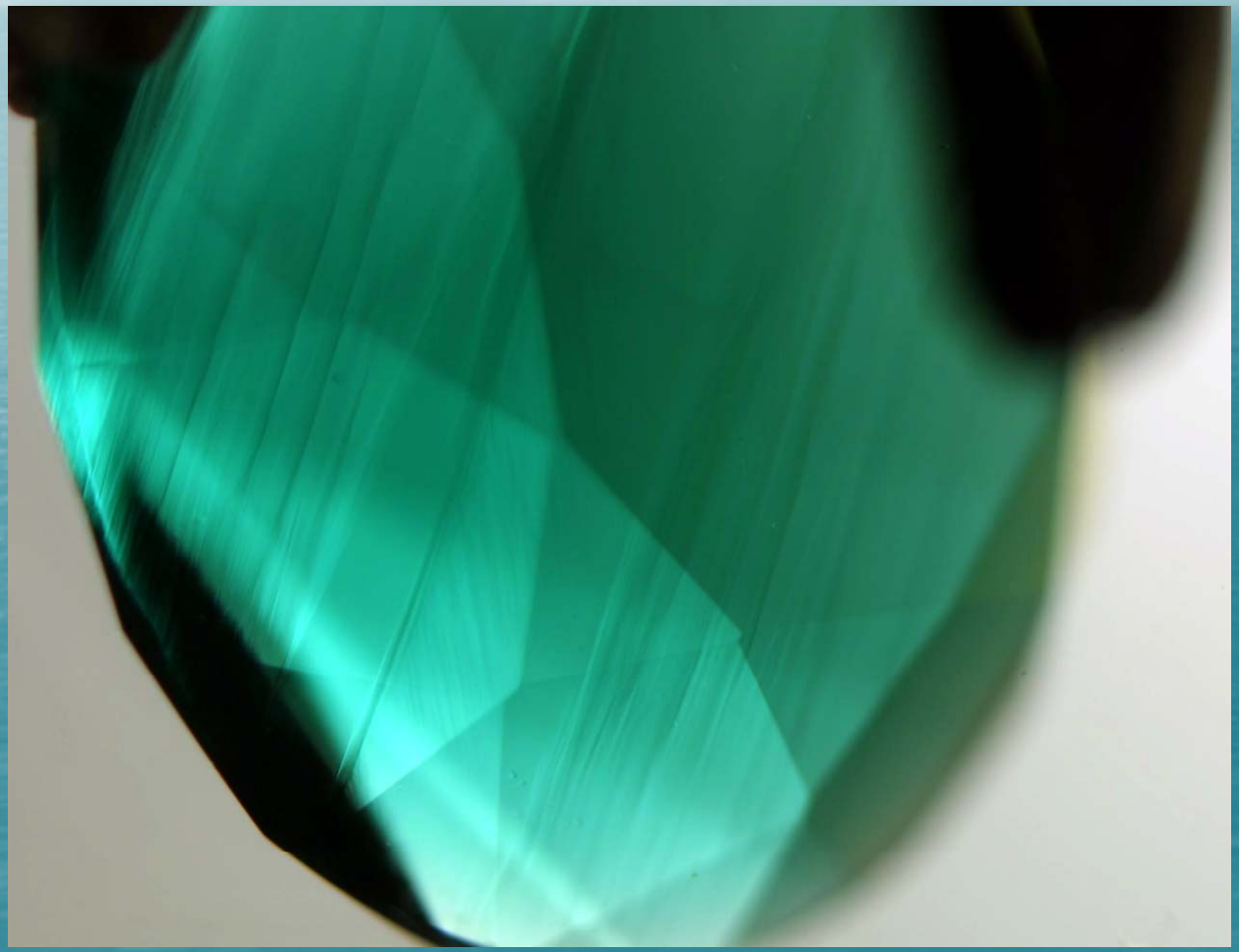
Inclusions in flux emerald

Metal (Pt) inclusions are result of container (chamber) partial dissolution

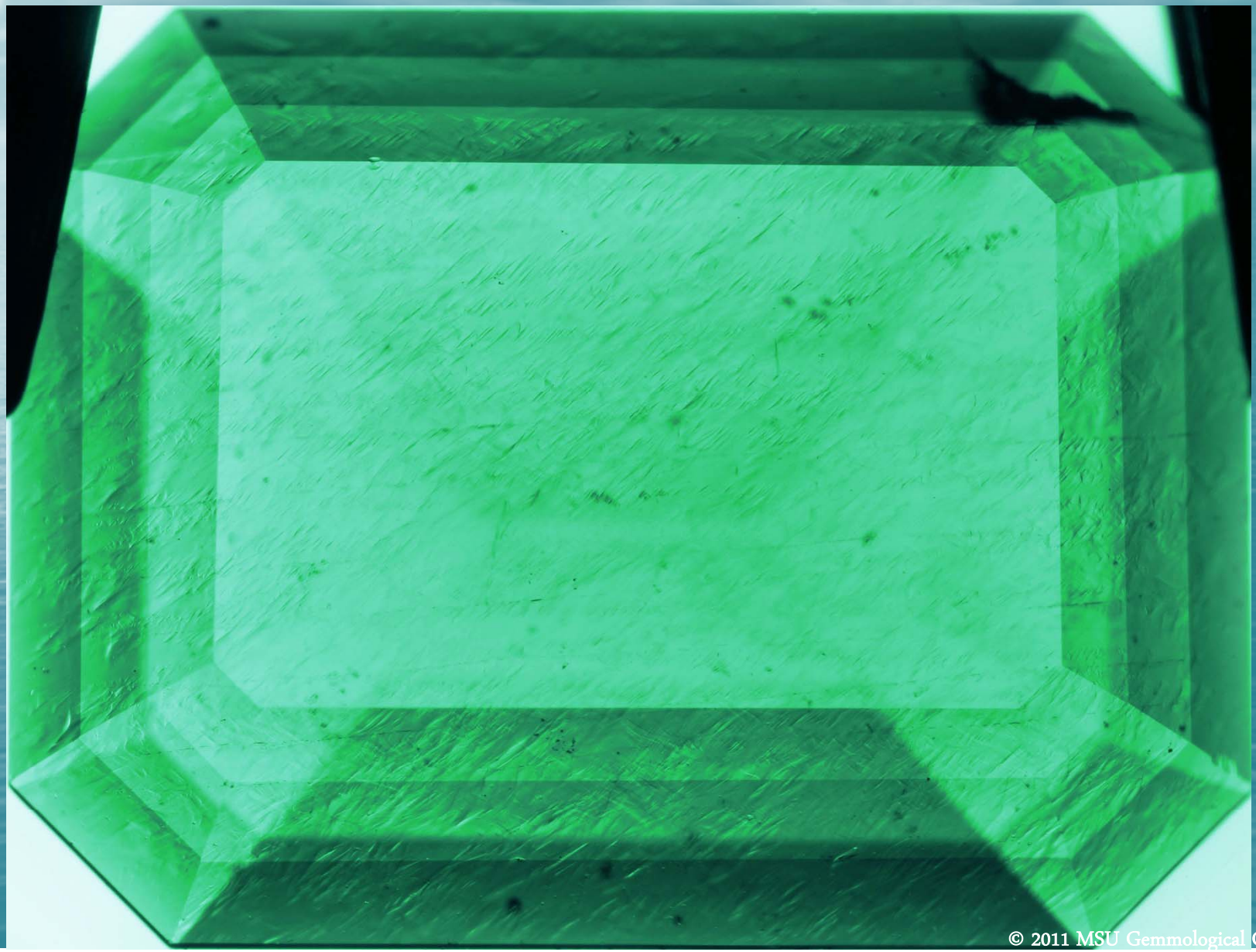
“Veils” in synthetic flux emerald



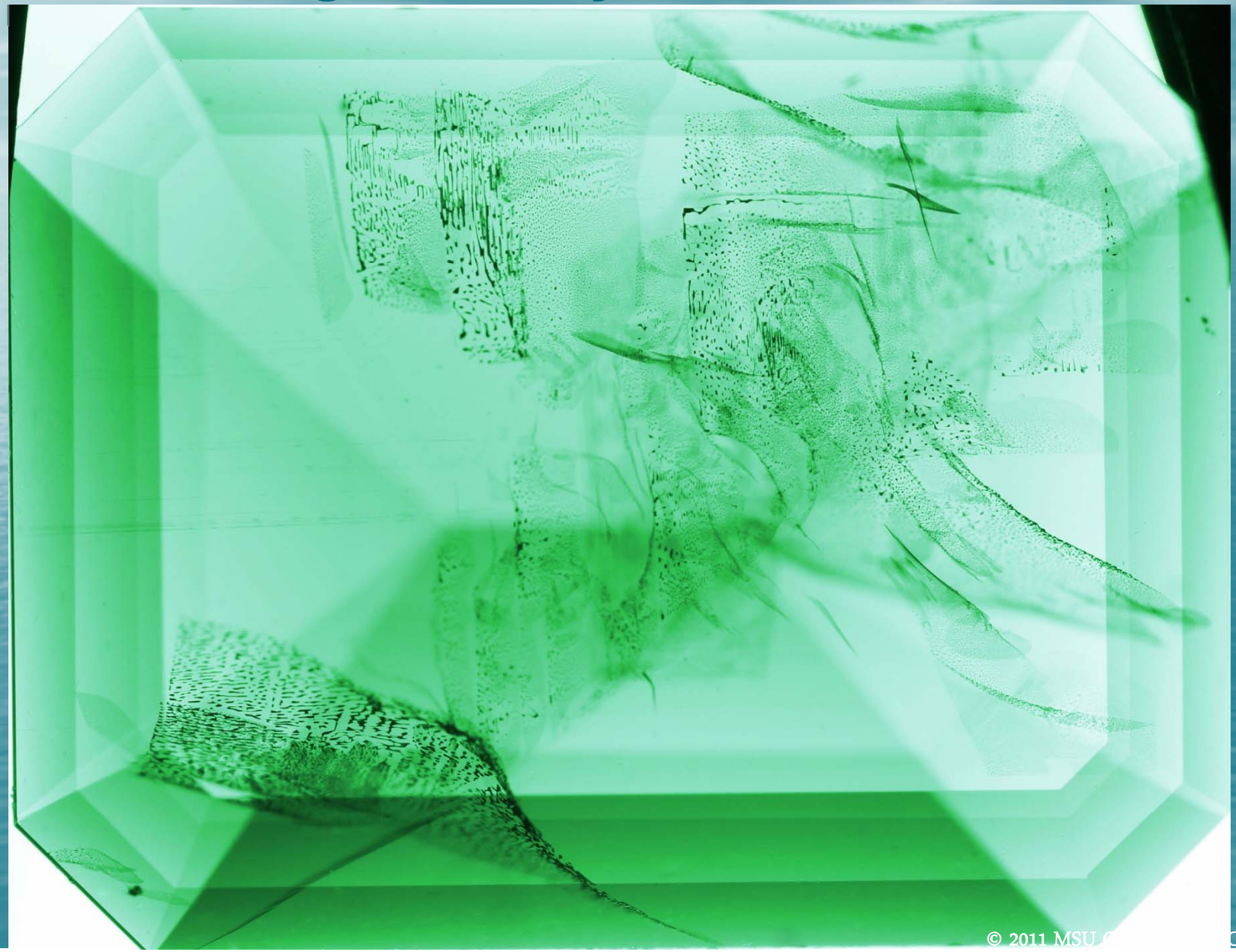
Undulating growth structure in synthetic hydrothermal emerald



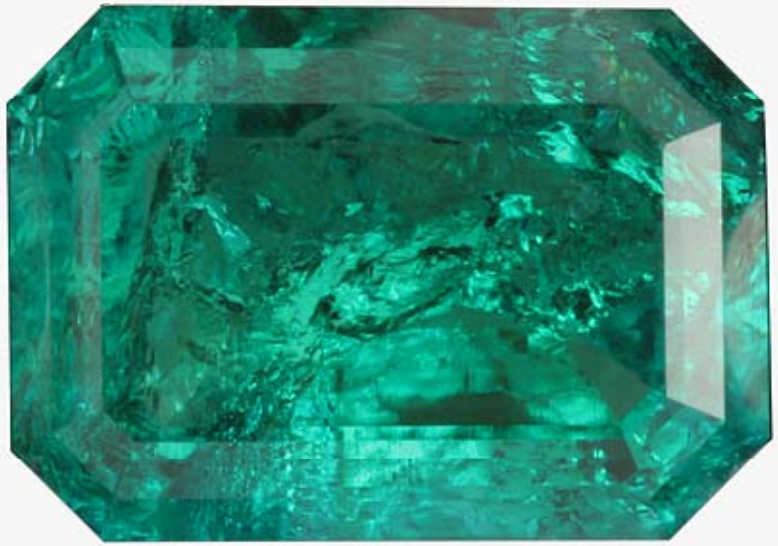
A hydrothermal synthetic emerald

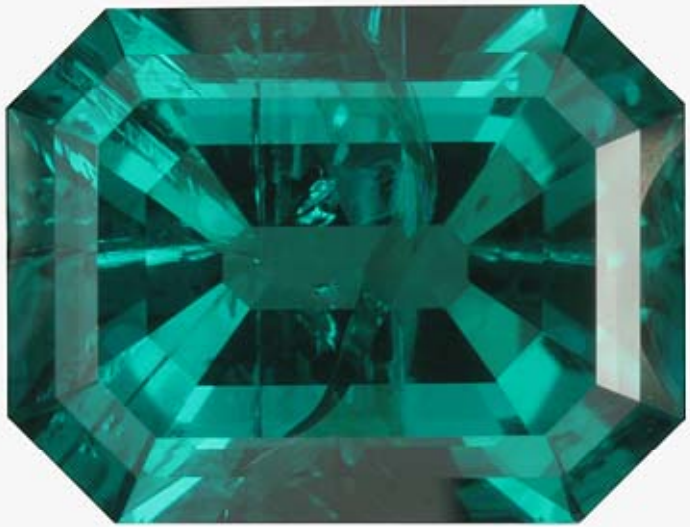


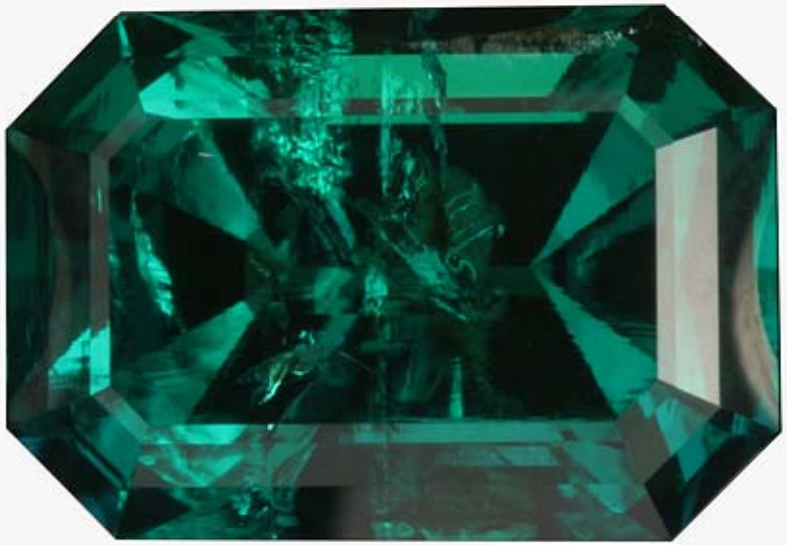
A flux grown synthetic emerald



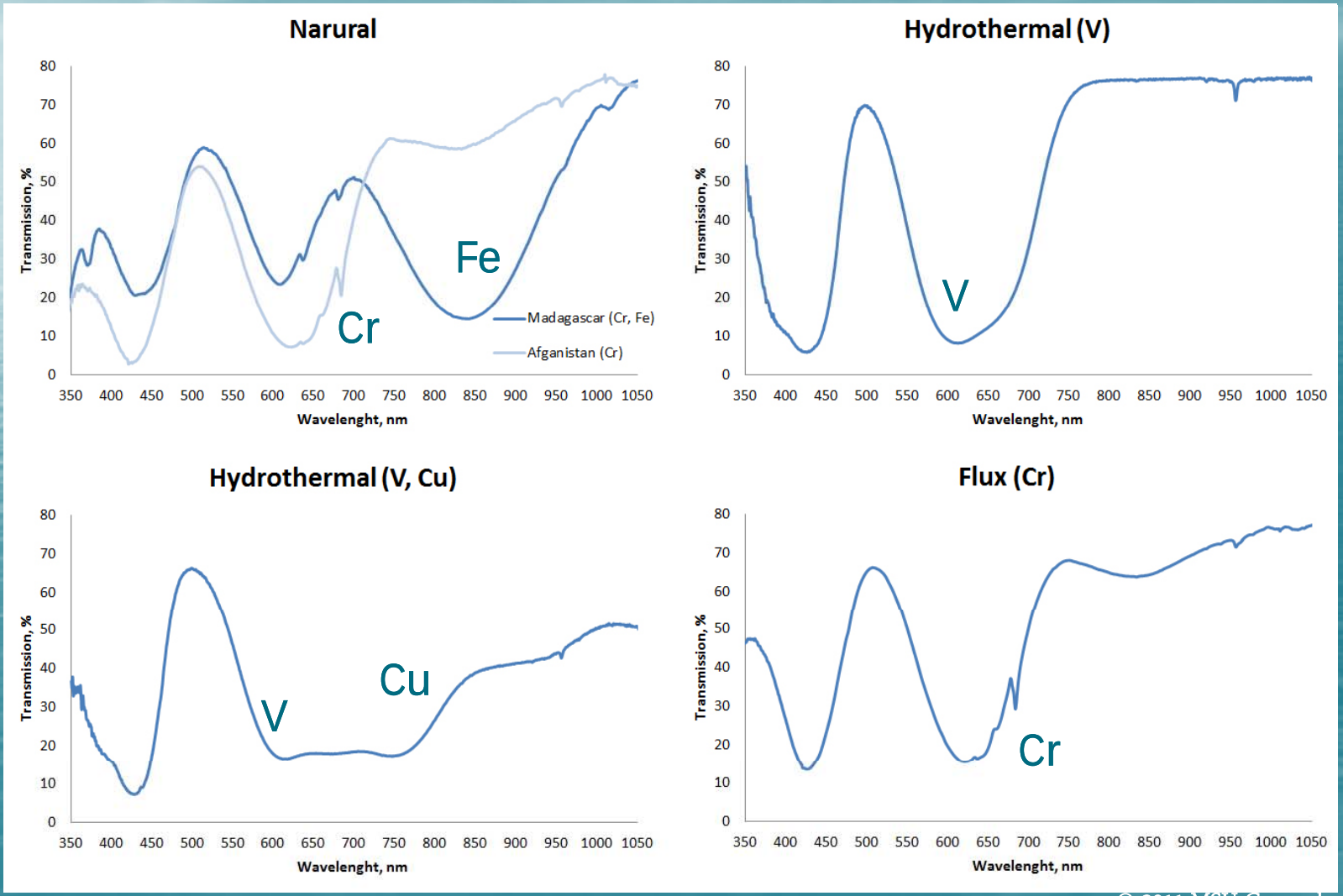
Synthetic emeralds with cracks





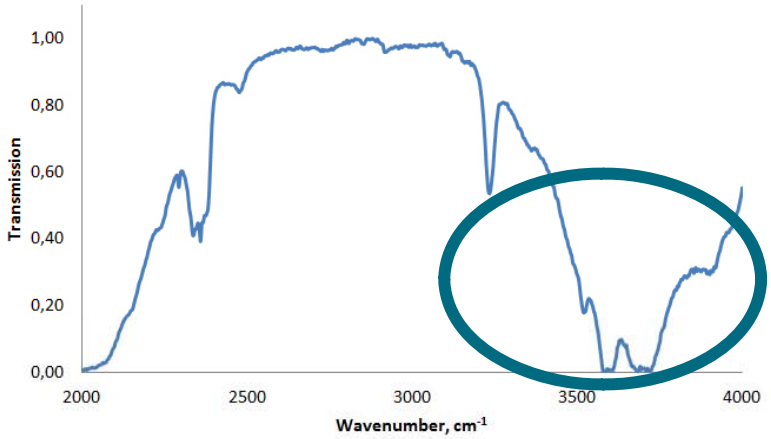


Visible range spectroscopy (transmission)

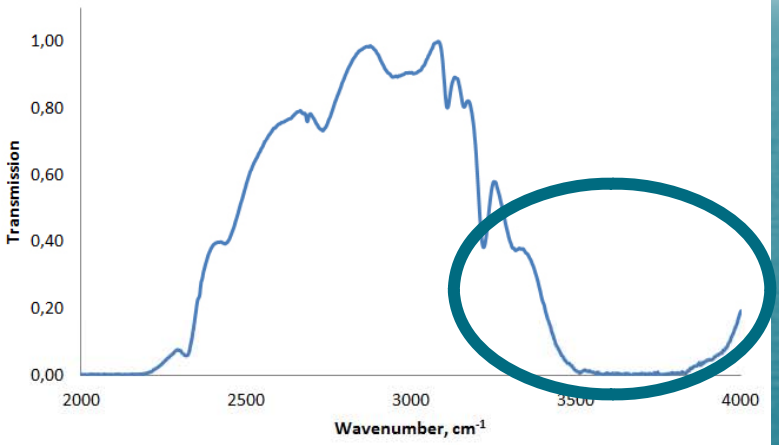


Infrared spectroscopy

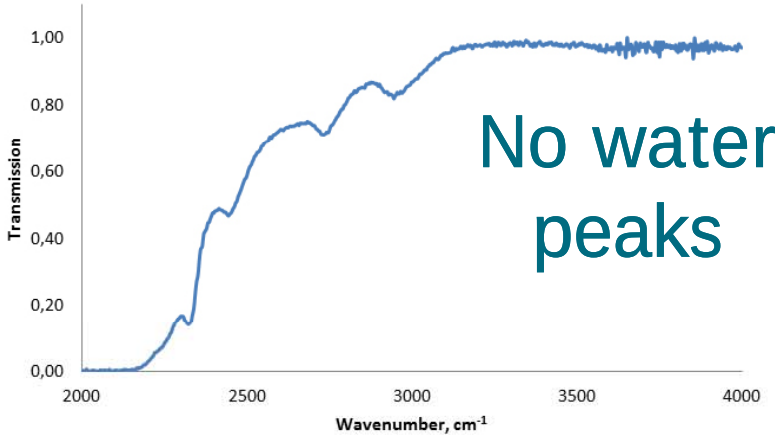
Natural (Columbia)



Hydrothermal

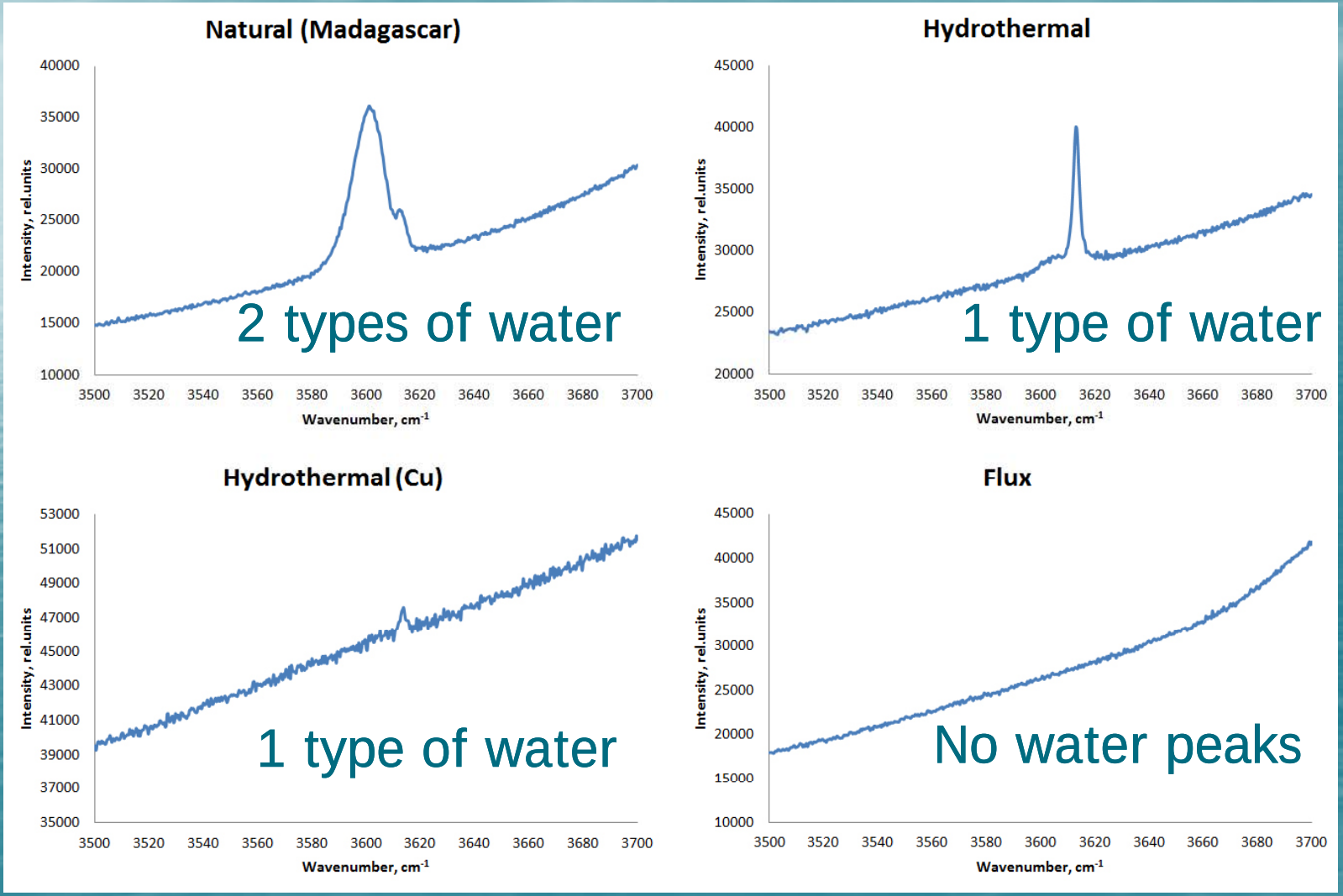


Flux



No water peaks

Raman spectroscopy



Trace element chemistry

Oxides (wt. %)	Hydrotermal Emerald	Hydrotermal Emerald	Hydrotermal Emerald	Hydrotermal Emerald	Hydrotermal Aquamarine	Flux	Flux	Malossi
Na2O	0,29	0,53	0,24	0,31	0,22	bdl	bdl	bdl
MgO	0,24	bdl	bdl	bdl	bdl	bdl	bdl	bdl
K2O	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Fe2O3	bdl	14,07	bdl	bdl	5,32	bdl	0,08	bdl
Cr2O3	bdl	2,56	bdl	bdl	bdl	1,56	1,93	1,96
V2O3	bdl	bdl	2,84	1,61	bdl	bdl	bdl	bdl
CuO	bdl	1,27	bdl	bdl	2,63	bdl	0,12	bdl
NiO	bdl	1,00	bdl	bdl	bdl	bdl	bdl	bdl
Cl	0,46	0,43	0,44	0,32	0,39	0,28	0,38	0,06

bdl – below detection limit

Trace element chemistry

Oxides (wt. %)	Hydrotermal Emerald	Hydrotermal Emerald	Hydrotermal Emerald	Hydrotermal Emerald	Hydrotermal Aquamarine	Flux	Flux	Malossi
Na2O	0,29	0,53	0,24	0,31	0,22	bdl	bdl	bdl
MgO	0,24	bdl	bdl	bdl	bdl	bdl	bdl	bdl
K2O	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Fe2O3	bdl	14,07	bdl	bdl	5,32	bdl	0,08	bdl
Cr2O3	bdl	2,56	bdl	bdl	bdl	1,56	1,93	1,96
V2O3	bdl	bdl	2,84	1,61	bdl	bdl	bdl	bdl
CuO	bdl	1,27	bdl	bdl	2,63	bdl	0,12	bdl
NiO	bdl	1,00	bdl	bdl	bdl	bdl	bdl	bdl
Cl	0,46	0,43	0,44	0,32	0,39	0,28	0,38	0,06
Oxides (wt. %)	Columbia	Urals	Afganistan	Kazakhstan	Austria	Madagascar	Norway	Australia
Na2O	0,68	1,53	1,50	0,12	1,93	2,00	0,11	0,63
MgO	1,02	1,55	1,85	0,08	2,15	3,08	0,10	0,81
K2O	bdl	bdl	bdl	bdl	bdl	0,18	bdl	bdl
Fe2O3	bdl	0,45	0,42	0,32	0,60	1,52	0,24	0,17
Cr2O3	0,17	bdl	0,67	0,12	0,14	0,28	0,19	0,65
V2O3	0,19	bdl	0,15	0,12	bdl	0,05	0,51	bdl
CuO	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
NiO	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cl	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Discussion

- Synthetic emeralds are generally more internally clean but can contain inclusions, cracks, and growth structures
- Flux emeralds do not contain water
- Natural emeralds contain two types of water
- Synthetic emeralds can be distinguished from natural ones by trace element analyses

Conclusions

- Long history of synthetic emeralds allow studying their properties
- Properties depends on growth method, producer, and color controlling elements
- Latest synthetic emeralds are closer to natural ones by color and microscopic features
- Difficult stones require advanced identification techniques
- At the moment 100% of synthetic emeralds can be reliably identified

About Polartec ®

Malden Mills Industries, Inc. was founded in 1906 in the town of Malden, Massachusetts. The company originally produced wool sweaters and bathing suits and later expanded to include uniforms to fulfill U.S. military contracts through World War II. After the war, in addition to wool, the company began to develop man-made fiber capabilities to respond to shifting post-war markets. In 1979 Malden Mills introduced its first branded synthetic apparel fabric. Creation of Polarfleece® revolutionized the way the world dresses for cold weather. Today most consumers own multiple garments in this category and depend on them on a daily basis. Polarfleece® was a major textile innovation recognized by Time Magazine as one of the 100 most important inventions in the 20th century. In 1991, building on the incredible success of Polarfleece®, Malden Mills introduced the Polartec® collection of performance textiles. Today, there are over 400 different styles of Polartec®, and in 2007 the company's named changed from Malden Mills to Polartec LLC.

Source: www.polartec.com

Literature

1. Houng L., Hager T., Hofmeister W. 2010. Confocal Micro-Raman spectroscopy: A powerful tool to identify natural and synthetic emeralds. Gems&Gemology, Spring 2010, pp. 36-41

2. Kopchikov M., Shelementiev Y. 2003. Synthetic hydrothermal beryl of red, green and blue color: the identificational propertis. Gemmologcal Bulletin, No 10 (in Russian)

3. Schmetzer K., Schwarz D., et al. 2006. A new type of Tairus hydrothermally-grown synthetic emerald, coloured by vanadium and copper. J. Gemm., 2006, 30, 9