

## Investigations of a synthetic turquoise

Pristacz, H.<sup>1,\*</sup>, Wildner, M.<sup>1</sup>, Hammer, V.M.F.<sup>2</sup>, Libowitzky, E.<sup>1</sup>

<sup>1</sup>Institut für Mineralogie und Kristallographie, Universität Wien, Althanstr. 14, 1090 Wien, Austria

<sup>2</sup>Mineralogisch-Petrographische Abt., Naturhistorisches Museum, Burgring 7, 1010 Wien, Austria

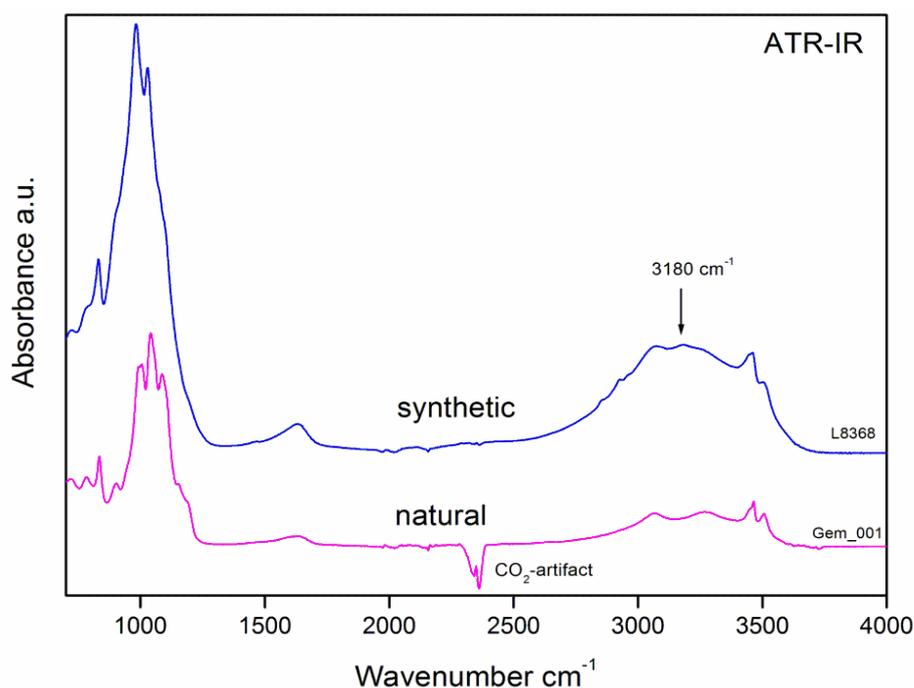
\*e-mail: [helmut.pristacz@univie.ac.at](mailto:helmut.pristacz@univie.ac.at)

A blue coloured stone, labelled as “synthetic turquoise” L8368, provided by the Natural History Museum Vienna, Austria, was investigated in the present work. Blue natural turquoise from Sleeping Beauty Mine, Arizona, USA, was used as reference material, as it has a reminiscent colour to “Gilson-created Turquoise”.

For the investigation of synthetic turquoise a combination of Raman spectroscopy, infrared (IR) spectroscopy, ultraviolet-visible-near infrared (UV–VIS–NIR) spectroscopy, powder X-ray diffraction (PXRD), and handheld energy-dispersive X-ray fluorescence (EDXRF) spectrometry has been employed. The distinction between natural and synthetic turquoise should be possible due to the observation of blue particles in a whitish ground-mass under magnification, as described by Eppler (1984) and Webster (1975).

Raman spectroscopy can be useful for the identification of natural and polymer-impregnated turquoise. The disadvantage of this method, however, is that the Raman signal of natural and treated turquoise is often heavily affected by strong luminescence phenomena. The Raman spectra of the synthetic turquoise accorded with those of the natural reference from Arizona, and showed no additional bands. Therefore it was not significant in that case.

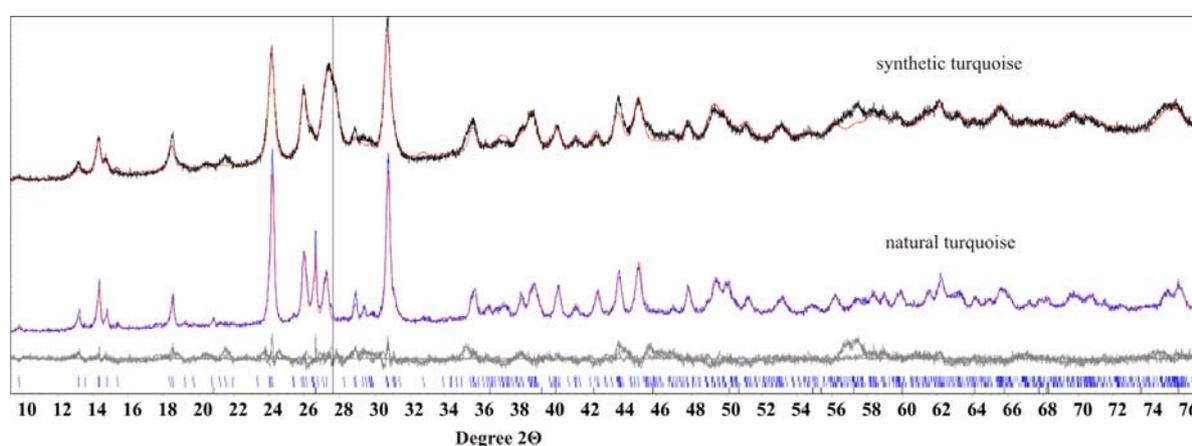
IR spectra were recorded with the attenuated total reflectance (ATR) technique. Synthetic turquoise exhibits smoother spectra when compared with natural turquoise, presumably due to a lesser degree of crystallinity (see also PXRD pattern in Figure 2). In addition to the characteristic spectra of natural turquoise, an absorption band at  $3180\text{ cm}^{-1}$  is present, as shown in Fig. 1.



**Fig. 1.** ATR-IR spectra of synthetic turquoise vs. natural turquoise.

O'Donoghue (1997) mentioned already for both natural and synthetic turquoise a weak absorption band in the visible range at 432 nm ( $23\,148\text{ cm}^{-1}$ ), but it was misinterpreted as related to copper. He noted further that the best method of discriminating is testing under the microscope. Therefore diffuse reflectance spectra of the two samples were recorded in the UV–VIS–NIR spectral region ( $32\,000\text{--}5\,000\text{ cm}^{-1}$ ). Natural turquoise includes two broad absorption bands near  $11\,500$  and  $15\,000\text{ cm}^{-1}$ . These two broad low-wavenumber bands are very probably related to  $\text{Cu}^{2+}$ . In addition, narrow bands at  $23\,200$  and  $23\,800\text{ cm}^{-1}$  can be attributed to the spin-forbidden field-independent  ${}^6\text{A}_{1g}(\text{S}) \rightarrow {}^4\text{A}_{1g}/{}^4\text{E}_g(\text{G})$  transitions of  $d^5$  configured  $\text{Fe}^{3+}$  in octahedral coordination (e.g. Spinolo et al. 2007) such as the Y site in turquoise. Spectra of the synthetic turquoise show only one broad band near  $13\,000\text{ cm}^{-1}$ .

For PXRD the sample material was milled in an agate mortar and prepared on a Si low-background holder. The synthetic sample obviously has the same crystal structure as natural turquoise. Synthetic turquoise shows a pattern of broader peaks and an undefined additional peak at  $27.63^\circ 2\theta$  (CuK $\alpha$  radiation) as depicted in Fig. 2.



**Fig. 2.** PXRD pattern of synthetic turquoise vs. natural turquoise.

For the investigation of the chemical composition of the samples a handheld EDXRF spectrometer was used. Analyses of several natural turquoises resulted in different iron contents. In contrast, in the investigated synthetic turquoise, the iron K emission lines are absent.

As mentioned by Elwell (1979), turquoise was one of the first gem materials to be simulated by synthetics like glass, plastic, or pressed turquoise powder bonded with resin. The most simulants of turquoise today are coloured gemmagnesite and howlite, which easily can be distinguished by XRD. Until today the only “true” synthetic turquoise is that by Pierre Gilson, who started production in 1972, as published by Williams and Nassau (1976). Significant differences in the ATR-IR and the UV-VIS-NIR spectra, the PXRD and the EDXRF analyses, and even inspection under the optical microscope provide useful tools to discriminate between natural turquoise and synthetic “Gilson-created Turquoise”.

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