IN-SITU CATHODOLUMINESCENCE MICROSCOPY AND SPECTROSCOPY FOR THE ROBOTIC MISSIONS ON MARS: A REVIEW. A. Gucsik, Wigner Research Center for Physics, Hungarian Academy of Sciences, Konkoly Thege Miklós út 29-33, H-1121, Budapest, Hungary (sopronianglicus@gmail.com).

Introduction: Cathodoluminescence (CL) is an emission of photon in the wavelength range from UV through visible light to IR stimulated by high energetic electrons. Further readings for the basics of CL can be found in the reviews and books reported by [1-6]. This is a powerful, non-destructive technique, which allows us many applications in the geosciences as demonstrated by [1,2,4 and 7]. CL has applied to meteoritics to study of shock metamorphism, hydrothermal alteration products, and high-pressure polymorphs in meteorites as well as astrobiological aspects (e.g. [8]). However, the CL properties of planetary materials have not been extensively investigated and characterized up to date. Cathodoluminescence microscopy and spectroscopy applied to the planetary missions, especially for Moon and Mars, were proposed by Götze and Tempe [5], Gucsik et al. [9] and Götze & Gucsik [10].

Two other luminescence types such as thermoluminescence (TL-light is emitted upon heating of sample) and Optically Stimulated Luminescence (OSL-light emission is due to the ionizing radiation, which may be applied to the Planetary Sciences, as follows. Thermoluminescence (TL) analysis leads to dating of the formation or metamorphic ages in meteorites and estimating the depositional environments (e.g. aeolian or water) [11] as well as studying thermal effects on meteorites [12]. This is important for deduction of the rates of solar heating up to 10^5 years in the past, which can be useful to estimate perihelia distance, although the thermal effect depends on several properties of the given meteorite, including rotation, albedo, heat conductivity, as well as potential depth inside the source body. Luminescence dating is closely associated with solid-state properties of minerals in a meteorite. Exposures of radiation (throughout radiational ionization) can be investigated by CL method [13]. Optically stimulated luminescence (OSL) technique (blue stimulated luminescence) has been also applied for evaluation of the maximum intensity of radiation [11]. TL measurements also can aid to the estimation of certain orbital elements and therefore possible parent bodies of a given meteorite. This method is based on the maximum solar heating of meteorites during perihelia of their orbits [12]. More recently, SEM-CL instrument has been applied for studying Martian meteorites and analogous materials as a powerful technique for the clarification of the atmospheric-fluid-rock interactions, sedimentary processes as well as their high-pressure minerals (silica and feldspar) [8, 14-20].

The purpose of this study is to summarize the potential how to use the CL microscopy and spectroscopy, which may be applied to the planetary sciences, especially to the robotic explorations on Mars.

A prototype of the luminescence device for the Mars in-situ microscopy and spectroscopy: It has been clearly demonstrated in the previous paragraphs of this manuscript that luminescence would be applied for the in-situ study of the Martian rocks. *Figure 1* shows a prototype of a luminescence device, which can be used for both cathodoluminescence and thermoluminescence analyses of the samples. A conveyor belt transports samples (indicated by a robotic arm) to the sample holder, which are placed in a turntable with sample cups. This sample holder must be heated (at around 400 C) for the thermoluminescence measurements. The miniaturized X-ray source, for instance, MOXTEK Bullet can be used for the TL [21]. Both CL and TL detectors will be equipped by a photomultiplier (PMT) unit for the detection of the signal.

Therefore, the luminescence device shows some advantages for the in-situ mineralogical studies of Martian rocks as follows. This instrument provides information about the radiation dose (for instance, from the solar wind) on the surface of Mars, which would be used in a preparation of the human exploration. Moreover, it can give some details of the carbonate or phosphate minerals as indicators for the fluid-rock interactions on Mars. Furthermore, the combination of TL and CL methodologies provides prescreening of samples for sample return missions (e.g., [21]-and references therein).

The above-mentioned luminescence techniques do not require a complicated sample preparation as follows. The robotic arm collects a few grams of a bulk sample from the surface and then the conveyor transports it into the sample chamber. Moreover, the thin atmosphere in Mars provides vacuum as one of the required conditions for the proposed luminescence analysis above.

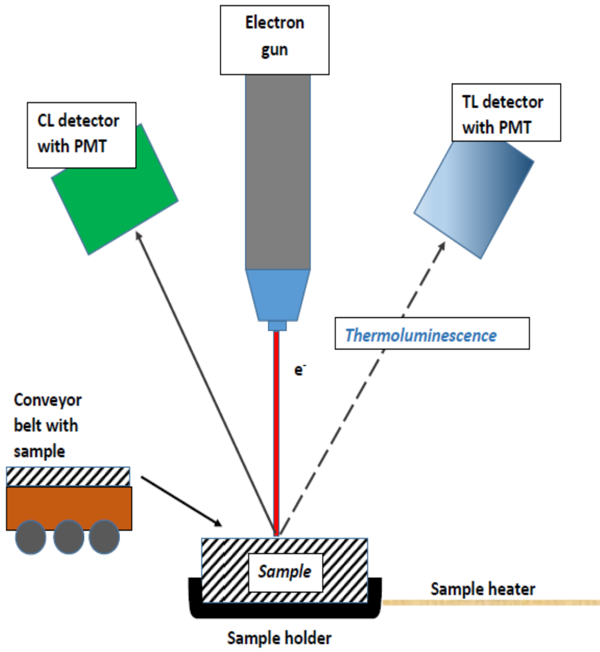

Figure 1. *A schematic figure shows a possible setup of the CL and TL detector on board of a robotic mission in Mars.*

Conclusions: In conclusion, the combination of CL imaging as well as CL spectroscopy is a potentially useful tool that can be used to characterize the mineralogical consequences of the atmospheric-fluid-rock interactions of Mars. Our results may also give new insight into the cathodoluminecence properties of the phosphate and carbonate minerals that occur in the Martian meteorites, which might be potential carriers of the remnants of primitive life forms. Further research, however, is required before an attempt can be made to sufficiently quantify these results to convert them into an application for the in-situ planetary robotic missions and their astrobiological aspects.

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