Modern garnet quality control: Micro-XRF and micro-computer tomographic investigations on Zillertal garnet raw products and jewellery pieces

Wagner, Simon[1]; Degenhart, Gerald[2]; Tropper, Peter[1]; Köchl, Roland[3]; Gilg, Hans Albert[4]

1 Institute of Mineralogy and Petrography, University of Innsbruck, Innrain 52, A-6020 Innsbruck, Austria; 2 Core Facility µCT, Medical University of Innsbruck, A-6020 Innsbruck, Austria; 3 Department of History and European Ethnology, University of Innsbruck, A-6020 Innsbruck, Austria; 4 Institute of Applied Geology, TU Munich, Germany.

Micro-XRF (X-Ray Fluorescence) is a powerful tool for the mineralogical and geochemical analysis of garnet raw products and jewellery. This method allows visualization of large-scale chemical zoning and identification of mineral inclusions in garnet, since electron probe microanalysis (EPMA) investigations are restricted to small areas of only several 100 µm. In addition, especially the non-destructive analysis and uncomplicated sample preparation are of enormous importance. Even simple qualitative analyses, such as elemental distribution maps or point analyses, give insight into chemical and geochemical differences between different garnets used in a piece of jewellery. In one piece of jewellery, at least three chemically different types of garnet could be discerned. Furthermore, these analyses can be used for quantitative chemical provenance investigations. To get quantitative results, two different methods are available, namely fundamental parameters method and the use of well characterized standards. Due to the formation conditions of the different garnets used in jewellery, chemical differences are visible in the measurements and allow statements to be made about the provenance. For instance, the difference between Zillertal and Bohemian garnet lies in the high Cr-contents of the latter and the high Fe-contents of the former. Another advantage of using the micro-XRF is that compositional zoning of large (several mm to cm) garnet crystals using major (Ca, Mn), minor (P, Ti) and trace (Y) elements can be visualized. This makes it also possible to distinguish between garnets from Zillertal, Radenthein, Ahrntal and Bohemia, as they formed under different P-T conditions as well as in different host rocks. The use of micro-computer tomography to characterize garnet quality, with respect to inclusion patterns, is particularly noteworthy and a novel technique for assessing garnet quality. The advantage in contrast to thin section analysis is that it is basically a non-destructive method and that there is a spatial distribution of quality characteristics such as chemical zoning and mineral inclusion assemblages, which can be visualized in 3D. First investigations were carried out on a garnet from a batch of “good quality” materials. The investigations revealed that the garnet contains numerous inclusions which in the end do affect its quality as a semi-precious gemstone.