

Detecting biosignatures associated with minerals by Geomatrix-Assisted Laser Desorption/Ionization Fourier Transform Mass Spectrometry (GALDI-FTMS)

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The ability to detect carbon signatures that can be linked to complex, possibly biogenic, organic molecules is imperative in research into the origin and distribution of life in our solar system particularly when used in conjunction with inorganic, mineralogical, and isotopic signatures that provide strong evidence for geochemical influences of living organisms on their environment. Ideally, the method used to detect these signatures must (i) accurately and automatically translate the organic and other information into usable forms, (ii) precisely distinguish such information from alternative compositions, (iii) operate with high spatial resolution coupled with precise location abilities, and (iv) require little to no sample preparation because of the potential for contamination. Geomatrix-assisted laser desorption/ionization (GALDI) in conjunction with a Fourier transform mass spectrometer (FTMS) has been used to determine the presence of bio/organic molecules (BOM) associated with different minerals and mineraloids including oxide, sulfate, carbonate, chloride, and silicate minerals. BOM is defined as an organic structure that can be produced by living organisms or derived from another organic compound made by living organisms (i.e., degradation product). GALDI requires no sample preparation because the mineral matrix assists desorption. Ultimately, however, the detectability of BOM is controlled by the desorption efficiency, ionization efficiency, and the specific experimental conditions. Results from experiments with combinations of known BOM and mineral standards indicated that the detectability of BOM increased with decreasing concentration, contrary to most analytical procedures. Results suggest that BOM when combined with certain minerals is more easily detected than when combined with other minerals. Such conclusions can guide selection of appropriate samples for sample return missions.

Geochemistry and geochronology of the Grenvillian granitic pegmatites of the Fort-Coulonge area, Québec: Complexity of the origin of the magma

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The Fort-Coulonge area is located in the Central Metasedimentary Belt (CMB) in the western part of the Grenville Province about 100km north-west of Ottawa, Canada. Two types of late orogenic granitic pegmatites are found in this area, intruding ductily deformed and high grade metamorphic rocks formed during the Proterozoic Grenvillian orogeny: (1) pink magnetite-bearing, locally zoned and foliated, aplitic to pegmatite (2 to 5 cm); (2) white unzoned, aplitic to pegmatite (2 to 5 cm) characterized by graphic and granophyric texture, white feldspars (K-feldspar and plagioclase), 1-5% biotite, with accessory molybdenite and tourmaline. The multiphase pegmatitic intrusions were generated at depth due to anatexis associated with late high-grade metamorphism during the Grenvillian Orogeny. The pegmatites of the western part of the Grenville previously dated at 937 to 980 Ma using whole-rock isochrons and at 1010 to 1060 Ma using U-Pb zircons which are 30 to 80 Ma younger than the peak metamorphism at this level of the Ottawa phase of the Grenville Orogeny.

Both pegmatites show some characteristics of NYF-type pegmatite and A-type granite such as low CaO, MgO, Sc, Cr and high Zr. All pegmatite samples have high silica and alkalis contents, with SiO₂ ranging from 63-80 wt.% and total K₂O+Na₂O varying from 5.1-10.2 wt.%. They also have Al₂O₃/(CaO-Na₂O-K₂O)>1, which indicates that they are peraluminous. The white pegmatite has lower Sr values (155-254 ppm) compared to the pink pegmatite (199-659 ppm). Thorium is frequently more abundant than uranium and Th/U ratio varies from 0.77 to 25.2, but is usually closer to 2 to 4. Generally indicators of fractionation, Rb/Sr and TiO₂/Zr ratio do not correlate with Th and (or) U values. These pegmatites fall in the anomalous granite field using Rb-Ba-Sr systematics. High Ba content in both pegmatites may be related to a small degree (less than 15%) of melting of a hybridized lower crustal protolith. The magma shows important crustal contamination characterized by high Rb and Th contents and by relatively enriched Ce and Sm relative to their adjacent elements. Importance of feldspar fractionation in the evolution of the magma is shown plotting Y/NB versus Ba/La with a trend parallel to the alkali feldspar fractionation.