Photoelectrons from minerals and energy of microbes in the critical zones

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Minerals and microbes interact at all time and spatial scales which have coevolved over much of Earth's history. Although the interactions occurred largely on the microscopic scale, the results were often macroscopic in the critical zone. Minerals contain nutrients and energy that microbes need to sustain their metabolism and growth. Transformation of the redox-sensitive elements from one valence state to another provides energy for driving the metabolic system of many microorganisms. On Earth, a predominant renewable energy source for powering natural bioactivity is solar light, and phototrophic microorganisms are adapted to capture this energy. While nonphototrophic microorganisms have been excluded from light-centered metabolism due to their lack of photosensitive cellular compounds. Nonetheless, this deficiency does not necessarily preclude an ability to derive energy indirectly from the Sun through semiconducting minerals. Upon solar irradiation, semiconducting minerals, such as sphalerite (ZnS), rutile (TiO2), goethite (FeOOH), and even birnessite (NaxMn1-xO23H2O) can give off photoelectrons, and these photoelectrons can be transferred to nonphototrophic microbes to support their growth. Recently, Lu et al presented evidences demonstrating solar energy mediated by semiconducting mineral photocatalysis, promoted the growth of some nonphototrophic bacteria. The growth of microbe, closely related with the photon quantity and energy, and well fitted the light absorption spectra of the semiconducting mineral. Further studies revealed that in natural soil system, semiconducting mineral photocatalysis influenced the microbial community. This solar energy utilization pathway by nonphototrophic microorganisms mediated by semiconducting mineral photocatalysis extends our knowledge on the use of solar energy by nonphototrophic microorganisms. This result manifested a novel microbial energy yielding pathway in addition to phototrophy and chemotrophy, in which photoelectron energy can be utilized by "photoelectrophy microorganism" via the photocatalysis of semiconducting minerals.

Key words: minerals and microbes, photoelectrons, critical zones