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New mineral occurrences and mineralization processes: Wuda coal-fire gas vents of Inner Mongolia

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Abstract

Five unique mineral assemblages that include the sulfates millosevichite, alunogen, anhydrite, tschermigite, coquimbite, voltaite, and godovikovite, as well as the halide salammoniac and an unidentified phase, according to X-ray diffraction and EDS data, were found as encrustations on quartzofeldspathic sand and sandstone adjacent to coal-fire gas vents associated with underground coal fires in the Wuda coalfield of Inner Mongolia.

The mineral assemblage of alunogen, coquimbite, voltaite, and the unidentified phase collected from the same gas vent, is documented for the first time. Coquimbite also occurs as rosettes secondarily nucleated on a cryptocrystalline mass of alunogen, coquimbite, voltaite, and the unidentified phase during storage in a sealed container at room temperature.

Field observations, analyses of vent gases, SEM images, and mineral compositions suggest that the sulfates millosevichite, alunogen, coquimbite, voltaite, godovikovite, and the unidentified phase, crystallized in response to a complex sequence of processes that include condensation, hydrothermal alteration, crystallization from solution, fluctuating vent temperatures, boiling, and dehydration reactions, whereas the halide salammoniac crystallized during the sublimation of coal-fire gas. Tschermigite and anhydrite formed by the reaction of coal-fire gas with quartzofeldspathic rock or by hydrothermal alteration of this rock and crystallization from an acid-rich aqueous solution.

Variations in the mineral assemblages found at five gas vents are possibly due to differences in coal-bed chemistry, exchange reactions involving coal-fire gas, and the composition of sediment, rock, and aqueous solutions prior to the exhalation of gas at the surface, as well as the temperature and cooling rate at a vent.

Few studies have addressed the interaction of coal-fire gas with sediment, rock, and aqueous solutions and the subsequent mineralization processes. Coal fires present opportunities for discovering rare and new mineral occurrences. These minerals have potentially important environmental significance and may be vectors for the transmission of toxins. Coal fires also provide insight for the recognition in the geologic record of preserved mineral assemblages that are diagnostic of ancient fires.