A NEOGENE WEATHERING ORIGIN OF A JAROSITE ORE FROM A CARBONIFEROUS PYRITE-CLAY DEPOSIT IN NORTH CHINA CRATON. Xuefei Liu[1*], Qingfei Wang[1], Yongbo Peng[2], and Huiming Bao[2*]. [1]State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083, China. [2]Department of Geology & Geophysics, E235, Howe-Russell-Griffin Geosciences Complexes, Louisiana State University, Baton Rouge, LA 70803, U.S.A.

Introduction: Jarosite has been discovered throughout Meridiani Planum, in several patches at Mawrth Vallis, Noctis Labyrinthus, Ophir Chasma, and along the southern wall of Ius Chasma. Proposed formation models include groundwater emergence or pooling water being evaporated locally[1-4] or "weathering of sulfur-rich minerals"[5]. At chemistry level, these two models are not different; both would require the interaction between clay minerals and sulfuric acid. In terms of surface condition, subsequent evaporation seems necessary although some suggested low temperature as well. Jarosite on current martian surface condition is stable and potentially retains "textural, chemical, and isotopic evidence of past history" [6]. Martian jarosites may have single or multiple origins. Therefore, exploring terrestrial jarosite formation models can offer references for understanding early and later martian surface environment and processes.

Terrestrial jarosite has been examined in diverse environments[7-8]. Here we report a new-type, highly enriched jarosite ore deposit that may shed lights on formation mechanism and model of the martian jarosites. Along the south margin of the North Chain Craton, a large-scale (~200 km^2) jarosite ore horizon was discovered in the Carboniferous clay deposit at Sanmenxia area. This site is special in that it is so far the only place on Earth surface where jarosite content reaches as high as 70%. It is expected that the basic chemistry for the formation of jarosite should be the same as that on Mars, although the environmental condition may have been different, i.e. warmer and wetter than on Mars.

Methods: To test this hypothesis, we built a formation model for the Sanmenxia jarosite ore by collecting a set of geological, petrographic, mineralogical data along with ages from K-Ar dating and multiple oxygen (including triple oxygen $\Delta^{17}O$) and sulfur isotope data on the ore bodies and associated sediments.

Results and discussion: Jarosite occurs in the clay-rich layers of the Carboniferous Benxi Formation. The clay-rich layer consists of jarosite, illite, anatase, goethite, and minor plagioclase, alunite, and siderite, which overlies a weathered crust which is composed of halloysite, illite, alunite, hematite, gypsum, and goethite. The weathered crust gradually transforms downward into Ordovician carbonate rocks that contain abundant evaporites. Chemical composition and crystal structure analyses show that the jarosite belongs to the H^3O-jarosite type with approximately 10% mol H^3O occurring at the A site, suggesting a supergene genesis for the jarosite. The $\delta^{34}S$ (-5.4~13.7‰), $\triangle^{17}O$ (-0.22~-0.06‰), and $\delta^{18}O$ (-6.3~ -1.0‰) values of jarosite suggest that abundant sulfuric acid was generated through the oxidation of pyrite interbedded with the clays. Those pyrite deposits were deposited in karstic depressions where sulfate-rich (dissolved from underlying evaporites) surface or groundwater were accumulated and microbial sulfate reduction was active at Carboniferous (~320 Ma) when the pyrite and clay co-deposited. The K-Ar ages of the jarosite range from 7.4 to 4.7 Ma, indicating that the Carboniferous pyrite-clay deposit in Sanmenxia area was uplifted in the Neogene, possibly driven by the India–Asia convergence. The uplift exposed the pyrite to oxidizing water and the oxidation generated abundant Fe^{3+}, SO_4^{2-} and acidity. The acidity released abundant K^+ from illite minerals in the clay-rich layer created a favorable chemical condition for the formation of a massive-volume and high-purity jarosite ore.

Three key but rare conditions in a continental deposition setting have resulted in the Sanmenxia jarosite ore formation: 1) the karst depression created a water-body that is reduced; 2) underlying Ordovician rocks provided ample dissolved salts including sulfate into the water-body where a sustained microbial sulfate reduction and pyrite precipitation had occurred; and 3) intermittently illite-rich clays were transported from nearby weathering crust and deposited together with pyrite in this water-body.

Implications: Our Sanmenxia jarosite ore formation model has two major martian implications. 1) If early formed phyllosilicates are K-rich and abundant, the addition of any source of sulfuric acid, either as acid fogs from volcanism or as product of oxidation of sulfide minerals in glacial meltwater, can produce the observed jarosite on martian surface. 2) The presence of jarosite on martian surface does not exclude the existence of episodically wet and warm surface condition on early Mars.

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