The occurrences of Taihu lake iron-rich concretions indicate their formation relating to airburst fallout deposition rather than groundwater colloidal deposition. Zhidong Xie, Shuhao Zuo. State Key laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing, P. R. China, zhidongx@nju.edu.cn.

Introduction: This article is to describe the details of occurrence of Fe-rich concretions in a specific mud layer in vicinity of Taihu lake, Southeast of China. It includes the distribution of the mud layer, the sandwich section of the mud layer, and occurrences of iron rich concretions. The possible origins of the specific mud layer and the iron-rich concretions are discussed. The goal of the paper is to answer the questions of the origin of the Fe-rich concretions whether it is related to an airburst fallout deposition from air, or a groundwater colloidal deposition in mud layer[1, 2].

The term “concretion” is used in this paper to indicate the texture of these siderite-quartz rich materials, not infer the water sedimentary origin.

Discovery History: It has been known for a long time that Fe-rich materials are dispersed in the mud layer in vicinity of Taihu lake. Ancient records show that around 600 hundreds years ago, stone-rods were found during foundation construction by a local officer. Local farmers discovered abundant Fe-rich materials dispersed in the farm fields, especially in the rice fields when they grew rice 40-60 years ago. Up to today, there are abundant finger-like hard stone rods in the farm fields. People call them “mud snag” or “mud stick”. Hard bean-sized spherules were found too, which were called “iron particles” or “iron sands” . In addition, local fishermen around Taihu lake found abundant heavy iron-rich stone existing under the lake water too. They do not like those iron-rich stone because they are hard and heavy, always damage the fish nets. In recent literature, researchers report there are kilometers long Fe-rich spherules under Taihu lake, they call them as “Fe-Mn concretions”[3].

The wired-shaped Fe-rich materials were collected as strange stone and were paid attention by local citizens and geologists almost ten years ago, after dredging of mud layer of Shihu lake, a small lake in Suzhou city not far away from Taihu lake. Samples were send to Nanjing university since early 2008 and many fields work were carried out. Most of the mud layer section do not keep long after muds are dug out because water release back again. Like Shihu lake, after dredging, water were put back again, all section were underwater now. However, continue mud dredging in vicinity of Taihu lake area give us chance to see many profiles in different locations. we do see the consistence from different locations ten kilometers apart. Here we describe one new cross section in edge of Taihu lake.

Occurrence: The mud layer bearing iron-rich concretions was sandwiched between bottom hard loess and top modern mud (Fig. 1). The age of hard loess is well known, ~11k to 20 k years ago. That means the bottom of mud layer bearing Fe-rich concretions cannot be older than 11 thousand years. The hard loess layer is yellowish, with non-uniformity contact plane with top iron-rich layer. Hard loess are known as wind weather products of northern loess plateau. Top modern mud layers are fine clay lake deposits and contain many modern biogenic debris. Modern plant roots can reach them and are rich in organic materials with dark color. The thickness of modern mud layer varies from one meter to four meters in general, from location to location. The contact plane between Fe-rich layer and top mud layer is non-uniform. Wave contact line can be seen from the cross section (Fig. 1). Some time, there are one oxidation zone above iron-rich layer (Fig. 1), with thickness of several centimeters and in oxidation yellowish color.

Iron-stained mud layer is sandwiched between yellowish hard loess and modern black mud layer. They contains iron-rich concretions. Most of them are siderite concretions with siderite as matrix and angular quartz grains as concretion debris in general [4, 5]. The siderite concretions can be grouped into three types: spherules (size from micron to mm, to even cm), elongated rods (short to long rods with diameter of less than 3 cm), and irregular concretions. The irregular shapes include massive, sheet, and tear shaped concretions. The age of the specific mud layer was constrained by C14 dating of charcoal wood and shell fragments in the same layer, suggests that the siderite concretions formed in about 7-8k years ago, or younger[1, 2].

Iron-rich mud layer has thickness of about 60 to 80 cm. Bean-sized iron rich spherules were seen on top of iron-rich mud layer almost at every location. It is homogenous distribution for spherules in small scale and in large scale. Rods and irregular concretions were found almost everywhere in large scale, at each location. However, it is not homogenous distribution in small meter-scales, they are nuggets and concentrating in one location or one strip zone, and may not found in nearby. Rods with length more than 30 cm are rare. Most of long rods were found vertically standing in iron-rich mud layer, reaching the lower part of the layer. The longest rod is 70 cm long with a tip inserting into the hard loess. Short rods and irregular concretions typically stand in the top one third part of iron-rich mud layer. Some of them were found in oxidation zone with yellowish color. In Fig.1, there are one oxidation zone containing many bean-sized oxidized spherules. In some cases, one rod has top part oxidized to yellowish, and lower part still keeps fresh with grey color, indicating a preservation environment changing.

Discussion: The iron-rich mud layer are found almost everywhere in vicinity of Taihu lake area. Mega construction investments help us to observe the cross sections. Combining all information from local personal communication, other resources and mainly the field work, there are one specific iron-staining mud layer contains iron-rich concretions. The Fe-rich concretions are widely dispersed in the specific Holocene mud layer of Taihu lake area indicating they are products of one young reduction event. If preserve condition is good enough, we should see this layer at the bottom of Taihu lake. In addition, iron-rich concretions were not only found at the bottom of mud layer of Taihu lake, even were found in higher ground place, especially along the foot of hills. The small creek mouths are places for concretions gathering. One explanation is that the concretions were moved together from higher ground or surrounding area. Even in higher hillside, tens meters higher than lake water, massive concretions are found too. It is difficult to explain they were formed in aqueous water deposition.

The existing of the oxidation layer between top modern mud layer and Fe-rich mud layer indicates that the top of Fe-rich layer once exposed in water or air directly. Preservation condition is very important for siderite concretions. Siderite concretions need reduction environment to preserve. For example, the top modern mud layer keeps the oxygen out and keeps Fe-rich layer in reduction condition and preserves the siderite concretions . After Fe-rich material were formed, they still need reduction environment to keep fresh. Otherwise, they will be oxidized, just like most of these materials in oxidation zone showing a lot of oxidization. Fresh concretions are only preserved under good conditions. In addition, the non-uniformity contact plane between Fe-rich layer and modern mud layer indicates a missing gap between two layers. The relationship between bottom loess and iron-rich layer is not uniform too, one is 11 k years older, one is 7 years old, 3 thousands years apart. One question is that whether or not the mud layer of iron rich layer is from the water deposition.

The non-uniformity contacts between middle layer and bottom or to top layer are consistent with literatures. Bottom hard loess layer is 11k years old, indicating Taihu lake area is a terrace 11 k years ago, no lake deposits yet [3] . According to Sun's paper [3], modern Taihu lake is pretty young, Taihu lake were formed only two thousands years ago. There are river beds under Taihu lake, and many archaeology sites were found in Taihu lake area. This opinion is against the hypothesis Taihu lake were covered by sea water in 7K years ago. Sun's paper think Taihu lake were formed much later due to three rivers to the ocean were blocked due the sand and mud deposition. Swamp becoming into big lake of Taihu lake were completed in two thousand years ago. The big question comes out, how lake basin were formed, and if there are no big lake at that time, how to form abundant iron-rich concretions in Taihu lake area.

It is not easy to explain the different types of Fe-rich concretions dispersed in the mud layer. Aqueous deposition or groundwater colloid deposition is more difficult to explain the occurrence of iron-rich concretions. It is difficult to explain why higher ground having concretions, even occurring in hillside. We need whole area were covered water, and deposit enough organic rich material to form reduction environment, then to form siderite concretions. It is big challenge to answer the questions by ground colloidal deposition. In another view, airburst fallout deposition hypothesis is ready and more likely to answer all questions by one event. More details can refer to our 2015 abstracts [1, 2]. It is on a going project from perspective of mineralogy and geochemistry. Questions and answer are widely open, but history event already happened and only one right answer waiting us to uncover.

Fig. 1 One cross section showing one sandwich profile with iron rich mud in middle, hard loess in bottom, and modern mud in top. Finger points one piece of oxidized spherules in oxidation zone.

References: [1] Z. Xie et al., 2015, 46th LPSC, 1754.pdf. [2] Z. Xie et al., 2015, MAPS 50, 5183.pdf. [3] S. Sun and Y. Wu 1987. *Chinese Science Bulletin.* 12:1329-1339. [4] H. Wang, Z. Xie, and H. Qian, 2009. *Geological Journal of China Universities*: 15: 437-444. (in Chinese). [5]Y. Dong, Z. Xie, S. Zuo, 2012. *Geological Journal of China Universities*: 18: 395-403. (in Chinese). [6] Y. He, D. Xu, D. Lu et al., 1990. *Chinese Science Bulletin,* 36 (10): 847-850. (in Chinese). [7] E. Wang, Y. Wan, Y. Shi, et al. 1993. 39 (5): 149-423 (in Chinese).

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