Origin of hydrothermally altered granites from the Yongping copper deposit, Jiangxi province, China: Constraints from immobile elements and Sr-Nd-Hf isotopes

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Yongping deposit is a large copper-polymetalic deposit located in the Qiantangjiang-Xinjiang intracontinental rift basin. The magmatic rocks in this deposit include porphyric biotite granite body and quartz porphyry dykes. Within and around the biotite granite body occurs porphyry-type and skarn-type Cu-Mo-W mineralization. Due to the variable degree of hydrothermal alterations both in the porphyric biotite granite and quartz porphyry, petrogenetic study of the rocks has not been carried out before. In this study, we apply a combined approach using mineral chemistry, major and trace elements, and Sr-Nd-Hf isotopes to reveal the origin of the petrogenesis and hydrothermal ore genesis. The biotite chemistry suggests a very high oxygen fugacity (fO_2) for the granitic magma, which is similar to those copper mineralization related granites in the Middle-Lower Yangtze regions. The chlorites altered from biotites in the quartz porphyry show Fe-rich, Mg-poor, Ti-poor characteristics, with Fe/(Fe+Mg) ratios of 0.72~0.76 and TiO_2 contents of 0.02~0.06 wt%, and the calculated temperatures are between 139 and 224 °C. In contrast, the chlorites from the porphyric biotite granite show lower Fe/(Fe+Mg) ratio (0.36~0.44) and higher TiO_2 contents (0.05~0.36 wt%), and the formation temperatures are higher from 229 to 346 °C which are in the same range as those mineralization temperatures (220~400 °C) deduced from fluid inclusion study. A systematic Sr-Nd-Hf isotope study indicates that the porphyric biotite granite has a wider range and higher εHf(t) and εNd(t) values of -0.1~-10.3 and -5.83~-7.95, respectively, which suggest a crust-mantle mixing characteristic for the petrogenesis. The quartz porphyry show lower εHf(t) and εNd(t) values of -8.4~-12.5 and -9.93~-10.2, respectively, suggesting little or less contribution from the mantle source. In summary, the granitic rocks at Yongping are mainly products of remelting of basement rocks of Middle Proterozoic age in the area, with small but variable amounts of mantle contributions.

Authigenesis of ferric smectite pellets and methane seepage in deep-sea sediments offshore SW Taiwan

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An unusual occurrence of ferric smectite pellets was identifed in a few deep-sea sediment piston cores collected from the gas-hydrate potential area offshore SW Taiwan. High methane concentrations in the bottom and pore waters with a shallow sulfate-methane interface are commonly characteristic of those sampling sites [1][2]. A model is proposed for the formation of ferric smectite pellets in a ~4.5-m piston core (GS5) sampled from the Formosa Ridge locating above the upper slab of a normal fault associated with nearby methane venting sites [3] with implications for methane activities.

A transition from dark brownish clay aggregates consisting principally of detrital montmorillonite, kaolinite, illite, chlorite, quartz, and feldspars to brownish green ferric smectite pellets occurred at a depth of ~2.5 m. The ferric smectite exhibits has a composition of 2.2-3.0 Fe per $O_{20}(OH)_4$ and is associated with abundant pyrite framboids, prominent pyrite overgrowth, and high magnesium calcite nodules (up to 17.3 mol.% $MgCO_3$) in the sediment matrix, and neoformation of filamentous pyrite grains within the pellets. An authigenic origin for the ferric smectite is evidenced by the ocuurence of delicate clay flocculation and aggregation microstructures and dissolution features of detrital grains within the clay pellets. The aforementioned mineralogical features are highly localized in the region.

We propose that an ion exchange process, near the seawater-sediment interface, between the clay-rich aggregates (probably excreted from organisms) and Fe^{2+}-rich fluid produced at nearby regions in a past period of methane venting activities and a low sedimentation rate were necessary for the formation of the ferric smectite pellets. Continuing in-situ methane seepage and oxidation are suggested to be responsible for the authigenesis of pyrite framboids and carbonate nodules immediately after the sedimentation of ferric smectite pellets and for the subsequent pyrite overgrowth and neoformation of filamentous pyrite with the ferric smectite serving as a source of reactive iron at depth.

[1] Yang (2006) *Cent. Geol. Surv. Rept.* **95-26-F**. [2] Lin (2006) *Cent. Geol. Surv. Rept.* **95-26-E**. [3] Lin (2006) *Cent. Geol. Surv. Rept.* **95-25-E**.