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Unravelling Complex Alteration by Dating Hydrothermal Titanite: Implications for the Use of Geochemical Vectoring Tools in the Propylitic halos of Porphyry-Type Ore Systems

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New geochemical exploration techniques that aim to detect orebodies at depth are currently being developed. In this endeavor, minerals in the propylitic halo of porphyry deposits have been of particular interest. Across the porphyry alteration halo, systematic changes have been identified in the chemical compositions of propylitic minerals, such as chlorite, which form the basis of tools that can vector towards mineralization. These tools are particularly useful in districts where orebodies may be blind and only the propylitic facies is visible at surface. However, porphyry systems form in active tectono-magmatic settings, so primary alteration can be overprinted by later events, particularly in older porphyry camps such as the Paleozoic Oyu Tolgoi Cu-Au deposits of southern Mongolia. For the application of mineral vectoring methods to be successful in such districts, an explorer must be confident that the mineral assemblage under investigation is related to the target porphyry event and that this alteration event can be isolated from preceding or overprinting events. Here, we present LA-ICP-MS U-Pb dates on in situ propylitic titanite from the Oyu Tolgoi district that identify three principal phases of hydrothermal activity that coincide with known magmatic events (Fig. 1): Devonian porphyry mineralization (~372 Ma); the intrusion of granodiorite plutons and andesite dikes in the Carboniferous (~350-310 Ma); and the emplacement of the Permian Khanbogd Granite alkaline batholith (~290-272 Ma). The titanite age-constrained alteration assemblages were then used to develop a mineral chemical classification scheme for other samples that allows chlorite in Devonian porphyry-related assemblages to be distinguished from the two later alteration events. By isolating the porphyry-related chlorite, it has been possible to demonstrate the validity of chlorite vectoring as applied to the known deposits and to generate new exploration targets in the district.

Fig. 1. Diagram comparing A) the hydrothermal titanite U-Pb ages from this study, to B) probability density plots of compiled igneous ages from intrusive units in the OT district.