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The utility of geochronology in constraining hydrogeological models: the application of U-Pb absolute ages to resolve timing of fluid flow in the Michigan Basin in southern Ontario

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Summary

Secondary dolomite, calcite and silica cements in veins and vugs are a common feature in sedimentary bedrock. These minerals, and their host structures, preserve a history of past fluid movement and provide important constraints on the development of models to explain the hydrogeological and hydrogeochemical evolution of sedimentary basins. The efficacy of the U-Pb system in dating secondary minerals such as calcite has been previously demonstrated in a number of environments. This contribution highlights the usefulness of LA-ICP-MS for U-Pb age dating these in-situ secondary minerals with an example applied to core samples taken from the eastern flank of the Michigan basin in southern Ontario.

Near-surface Devonian rocks have calcite vein infill ages from 80-100 Ma with evidence for younger infill down to 50 Ma. Calcite cement in sub-horizontal fractures near the base of the Silurian sequence records U-Pb ages of 318 ± 10 Ma by LA-ICPMS and 313 ± 1 Ma by ID-TIMS. Calcite from >650 m deep Ordovician carbonate rocks yields a Silurian age of 434 ± 5 Ma while dolomite and silica cements in Cambrian sandstone at the base of the sequence have an average U-Pb age of 320 ± 10 Ma. These results suggest that 1) shallow vein ages at depths <200 m reflect Cretaceous and Cenozoic movement of meteoric and glacial water 2) Ordovician hosted fluids are most likely a combination of infiltration of seawater from overlying evaporitic basins and hydrothermal solutions that infiltrated from below and remained unperturbed despite regional post-Paleozoic tectonic events and 3) the Cambrian sandstone has a distinctive initial common Pb end member which, when combined with previous hydro-geochemical and fluid inclusion studies, is interpreted to record episodic migration of saturated hydrothermal brine in this part of the Michigan Basin.

Taken together, the results show how U-Pb system geochronology produces hydrochronological models of fluid flow, which has the advantage of providing absolute rather than relative ages. These ages provide constraints for, and represent a complimentary tool in the development of, hydrogeological and hydrogeochemical models of subsurface fluid flow in the Michigan Basin.