600-million-year Crack-seal Veins Record Complex Tectonic and Fluid Flow Evolution in the NW Saudi Arabia

Adhipa Pamularso, Ardiansyah Koeshidayatullah, Abduljamiu Amao, Abdulwahab Bello, Faisal Al-Ghamdi, Muhammad Malik, Khalid Al-Ramadan

King Fahd University of Petroleum and Minerals

Abstract

The Ediacaran Period (635-538 Ma) was marked by considerable tectonic activity, including the end of the Pan-African episode - a long interval of mountain building, rifting, and reorganization spanning most of the Neoproterozoic Era. In Saudi Arabia, the Ediacaran outcrops were developed and preserved in several isolated half-grabens linked to the Ediacaran to early Cambrian Najd strike-slip fault system. Particularly in the study area, the Ediacaran outcrop is intensively fractured with a distinctive crack-seal veins morphology. Such fractures could provide insights into the structural evolution and paleo fluid flow from 600 million years ago to Recent times. However, little is known about the origin and timing of different structural-controlled diagenetic processes in the Ediacaran sequences across the Arabian Plate. This study focused on the structural diagenesis of these Ediacaran strata in order to understand the tectonic evolutions in Saudi Arabia and establish the possibility of correlating these events regionally and globally. Here, we examined precipitated veins along a well-exposed, 300 m thick Ediacaran host rock exposure by applying U-Pb dating; high-resolution geochemical analyses, carbonate clumped isotopes, fluid inclusions, advanced petrography analysis of Cathodoluminescence microscopy and SEM-EDX. The ongoing results show that the calcite veins appear in different stages, orientations, geometries, and mineralogy. The $\delta^{18}O$ and $\delta^{13}C$ isotopic compositions of the crack-seal veins vary between -10 to -9.3‰ and 1.3 to 1.9‰, respectively. On the other hand, the Mn-rich later phase veins, which cross-cut the crack-seal veins, indicate an isotopic composition of -10.9 to -10.6‰ for δ^{18}</sup>O and -18.2 to -15‰ for $\delta^{13}C$. Hence we argue that the structural diagenesis history in the study area comprises several distinct tectonic events and fluid circulation members along the fractures. Our findings offer a new understanding of paleo fluid circulation and also highlight the multi-proxy's potential for investigating the structural diagenesis of calcite veins in the Ediacaran host rock. Moreover, the correlation of these results with comparable data from several Ediacaran strata across Arabia and throughout the world is encouraging in the sense of global tectonic events.