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Impact of fracture stratigraphy on the paleohydrogeology of the Madison limestone in two basement involved folds in the Bighorn Basin (Wyoming, USA)

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Based on the study of the Madison Limestone at Sheep Mountain and Rattlesnake Mountain, a unique outcrop dataset including (1) facies and diagenenitc analyses, (2) vertical persistence and cement stratigraphy of vein sets and (3) fluid inclusions thermometry are used to demonstrate (i) the importance of the eo-diagenetic phases on reservoirs petrophysical and mechanical properties, and (ii) the impact of folding and fracturing on paleo-hydrogeology. The different phases of porosity and permeability development of the carbonates of the Madison Limestone occurred mainly during the syn-depositional eogenesis, the postponed eogenesis (reflux of brine during LFS3) and during the karstification at the end of the Mississippian. The early sealing by the Amsden Formation during the Early Pennsylvanian, limited the vertical exchanges and initiated the confinement of the Madison "aquifer". The burial of the Madison Limestone leaded to the occlusion of the pore network due to the calcite cementation in the distal parts of the platform whereas it leaded to the pore network development due to the crystallization of dolomite in proximal parts. Quantification of the vertical persistence of fractures shows that Sheep Mountain and Rattlesnake Mountain differ by the vertical persistence of the pre-folding Laramide vein sets, which are strictly bed-confined in Sheep Mountain but cut across bedding at Rattlesnake Mountain, whereas the syn-folding veins are through-going in both. The emplacement chronology and the various sources of the fluids responsible for the paragenetic sequence are based on isotope chemistry and fluid inclusions analysis of the matrix and vein cements. At Sheep Mountain and Rattlesnake Mountain, the two cements related to the burial are characterized by isotopic signatures of marine formation waters that were diluted during the karstification of the Madison Platform at the end of Mississippian. Meteoric fluids, presumably migrating during the Cenomanian from Wind River Range and Teton Range, recharge zones located in the south-west of the Bighorn Basin, were remobilized in the early bed-confined and through-going syn-folding veins of the Sheep Mountain Anticline. The former vein set drained only local fluids whose isotopic signature relates to an increase of temperature of the meteoric fluids during their migration, whereas the latter set allowed quick drainage of basinal fluids.