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Transboundary study of the Milk River aquifer (Canada, USA): geological, conceptual and numerical models for the sound management of the regional groundwater resources

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The Milk River transboundary aquifer straddles southern Alberta (Canada) and northern Montana (United States), a semi-arid and water-short region. The extensive use of this regional sandstone aquifer over the 20^{th} century has led to a major drop in water levels locally, and concerns about the durability of the resources have been raised since the mid-1950. Even though the Milk River Aquifer (MRA) has been studied for decades, most of the previous studies were limited by the international border, preventing a sound understanding of the aquifer dynamics. Yet, a complete portrait of the aquifer is required for proper management of this shared resource. The transboundary study of the MRA aims to overcome transboundary limitations by providing a comprehensive characterization of the groundwater resource at the aquifer scale, following a three-stage approach:

1) The development of a 3D unified geological model of the MRA (50,000 km^2). The stratigraphic framework on both sides of the border was harmonized and various sources of geological data were unified to build the transboundary geological model. The delineation of the aquifer and the geometry and thicknesses of the geological units were defined continuously across the border.

2) Elaboration of a conceptual hydrogeological model by linking hydrogeological and geochemical data with the 3D unified geological model. This stage is based on a thorough literature review and focused complementary field work on both sides of the border. The conceptual model includes the determination of the groundwater flow pattern, the spatial distribution of hydraulic properties, a groundwater budget and the definition of the groundwater types. Isotopes (^{3}H, ^{14}C, ^{36}Cl) were used to delineate the recharge area as well as the active and low-flow areas.

3) The building of a 3D numerical groundwater flow model of the MRA (26,000 km^2). This model is a transposition of the geological and hydrogeological conceptual models. A pre-exploitation steady-state model and a subsequent transient numerical model with several exploitation scenarios were developed. The numerical model aims to test the conceptual model and to provide a basis to assess the best possible uses of this valuable resource that is shared by Canada and the United States of America.

This study provides a unique approach with scientific tools for proper aquifer assessment and groundwater management at the aquifer scale, not interrupted by a jurisdictional boundary. These tools are combined and integrated into three models, which together will form the basis of reliable sustainable groundwater and aquifer management in cooperation, thus facilitating the creation of a system of transboundary water governance based on scientific knowledge.