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Using Comprehensive Biophysical Characterisation of Hydro-Geologic Landscapes to Constrain Surficial and Subsurface Fluid Flow and Solute Transport: An Example from Southern Rivers in Southeast Australia

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The geology in the transect from Canberra to the east coast of New South Wales (NSW), Australia, consists of three major groups. These include the rocks of the Palaeozoic Lachlan Fold Belt, Mesozoic Sydney Basin sediments and Cainozoic sediments. The Lachlan Fold Belt lithologies, in the study area, are characterised by an intensely deformed Ordovician turbidite basement overlain by Silurian and Devonian rift successions, with siliciclastic and volcanogenic sediment fill, bimodal volcanics and associated granitic intrusions. These rocks are unconformably overlain by thick, relatively flat-lying, Permo-Triassic glacial-periglacial, fluvial and shallow marine siliciclastic sediments of the Sydney Basin. Localised areas of Cainozoic gravels cover the palaeo-landscapes developed on the older rocks, and modern fluvial and coastal processes continue to modify the landscape.

Salt is concentrated in this landscape through aeolian accession, deposition from oceanic aerosols, or rarely as fossil (connate) salts. The redistribution of salts by the process of aeolian accession typically takes place when the salts are coupled with windblown dust known as parna. For south-eastern NSW, this dust originates from areas which are more arid, such as the western regions of the NSW and Victorian states. Aerosols from the ocean can be responsible for the deposition of salts up to a few hundred kilometres from their source. This process is responsible for a significant contribution of salt in the south-east of NSW, especially on the coastal plains and the eastern Southern Highlands. The presence of connate fluids is commonly associated with marine derived sediments. While many of the geological units of the Lachlan Fold Belt were marine deposits, these units have undergone up to four major folding and faulting events and many minor deformations. It is commonly believed that these units have been too intensely deformed, upthrust, eroded and flushed to allow the retention of any original salts deposited at the time of formation. In addition, many of the sedimentary units were formed in a fluvial environment and did not have associated marine salts at the time of formation.

In lowland areas, where landscapes are dominated by unconsolidated sediments, salts can be deposited and redeposited as solid grains, they can crystallise in pore spaces in the sediments and they can be adsorbed onto iron oxides and clay minerals. These salts can also be dissolved and mobilised into surface and groundwater systems and move through the landscape in this manner. In upland areas, the processes of distribution, storage and mobilisation of salts are similar, however there is typically more rock outcrop and the structure of the landscape is influenced by distribution of weathering products and unconsolidated materials.

To improve the understanding of the way in which salt is mobilised in different landscapes, it is important to understand the way in which water moves through the landscape, as it is the principle agent involved in the weathering of rocks to form regolith, and water mobilises salts contained in the regolith and fractured rock.

Biophysical characterisation of the landscapes developed on each of these geological units allows the constraint of salt storage and distribution across these landscapes. This can be used to inform the development of conceptual models for saline fluid flow. Development of Hydro-Geologic Landscape polygons, a scaled and modified Groundwater Flow Systems approach, describes areas with like biophysical characteristics within a landscape, and hence like salt storage capacity and fluid flow parameters.

Initially this work was used to characterise landscape areas for regional natural resource management (NRM) decision making, but at more detailed scale it has proven to be a useful applied tool for on-ground agricultural management and NRM at catchment and sub-catchment scale. Further, this work helps define a range of other NRM issues in addition to the storage and release of salts across the landscape. The Hydro-Geologic Landscape model can also be used to better define and manage the following: eroded, commonly sodic, landscapes; acid sulphate affected ground; intensely silicified and ferruginised landscapes; and also has applications with respect to carbon sequestration and water quality studies.