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How tritium illuminates catchment structure

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Streams contain water which has taken widely-varying times to pass through catchments, and the distribution of ages is likely to change with the flow. Part of the water has 'runoff' straight to the stream with little delay, other parts are more delayed and some has taken years (in some cases decades) to traverse the deeper regolith or bedrock of the catchment. This work aims to establish the significance of the last component, which is important because it can cause catchments to have long memories of contaminant inputs (e.g. nitrate).

Results of tritium studies on streams world-wide were accessed from the scientific literature. Most of the studies assumed that there were just two age-components present in the streams (i.e. young and old). The mean ages and proportions of the components were found by fitting simulations to tritium data. It was found that the old component in streams was substantial (average was 50% of the annual runoff) and had considerable age (average mean age was 10 years) (Stewart et al., 2010). Use of oxygen-18 or chloride variations to estimate streamflow mean age usually does not reveal the age or size of this old component, because these methods cannot detect water older than about four years.

Consequently, the use of tritium has shown that substantial parts of streamflow in headwater catchments are older than expected, and that deep groundwater plays an active and sometimes even a dominant role in runoff generation. Difficulties with interpretation of tritium in streams in recent years due to interference from tritium due to nuclear weapons testing are becoming less serious, because very accurate tritium measurements can be made and there is now little bomb-tritium remaining in the atmosphere. Mean ages can often be estimated from single tritium measurements in the Southern Hemisphere, because there was much less bomb-tritium in the atmosphere. This may also be possible for some locations in the Northern Hemisphere. Age determination on single samples allows the variation of mean age with streamflow to be investigated, as observed in the Toenepi Catchment in New Zealand where baseflow mean ages varied from 4 to 155 years depending on flow (Morgenstern et al., 2010).

References: Stewart, M.K., Morgenstern, U., McDonnell, J.J. Hydrological Processes 24(12), 1646-1659, 2010. Morgenstern, U., Stewart M. K., Stenger, R. Hydrology and Earth System Sciences 14, 2289-2301, 2010.