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What Controls the Formation of Large Surficial Uranium Systems? A comparative study of Langer Heinrich, Namibia and Yeelirrie, Western Australia

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Several workers have observed that the rank-size distributions of mineral deposits generally follow Zipf's Law in a given metallogenic province. Although Zipf's Law has been widely used for quantitative estimations of undiscovered resources, there are very few studies on the genetic significance of Zipfian distribution of mineral deposits. This contribution focuses on rank-size distributions of surficial uranium deposits in two best-known calcrete provinces of World, namely, Western Australia and Erongo Region of Namibia. We use intensive field studies, proprietary exploration data and new geochemical and geochronological data to analyze the genetic factors that characterize the largest deposit in each province, namely, Yeelirrie (in Western Australia) and Langer Heinrich (in Erongo), respectively, and differentiates them from the rest.

The Langer Heinrich deposit extends for over a 15-km length in seven high grade pods and contains approx. 60,000 t U_3O_8. The carnotite mineralization occurs at deeper stratigraphic levels within calcrete that cements poorly-sorted channel-fill clastic sediments such as conglomerate, grit and sand. The grain sizes vary from huge boulder to sand indicating high energy sedimentary environment. The mineralization is 1 to 30 m thick and is 50 to 1,100 m wide depending on the width of the palaeochannel. The Yeelirrie deposit is a near-surface ore body that extends over 9 km, is up to 1.5 km wide, up to 7 m thick with an average overburden of 7 m (Source: http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/australia.aspx). The total resources at Yeelirrie are approximately 63000 t U_3O_8.

In terms of the mineral systems components, the two deposits are unremarkable in terms of the uranium enrichment of granitic sources in the hinterland. The Archean granites forming the metal source for Yeelirrie and the Neoproterozoic Bloedkoppie and Salem Granites forming the source for the Langer Heinrich are rich in uranium, but not extraordinarily so. These rocks also occur in the hinterland of numerous other palaeochannels but none of those contain deposits as large as Yeelirrie or Langer Heinrich. Similarly the permeability of channel-fill sediments that form the pathways for uranium-enriched groundwater is generally the same in most palaeochannels of Western Australia. However, in the case of Erongo, the channel-fill sediments at Langer Heinrich are distinctly more permeable compared to other palaeochannels in the region as a consequence of high-energy depositional environment.

Our studies indicate that the large uranium accumulation at Yeelirrie and Langer Heinrich is mainly controlled by the channel morphology including low hydraulic gradients, confluence of tributary channels, presence of basement highs on the channel floor and impervious rocks across the channels that lead to pooling of uranium bearing ground waters. We outline different precipitation processes that regulated uranium precipitation in the above two channels. We also note the importance of long-term sustenance of mineral systems in formation of world-class surficial uranium deposits.