

Trace elements as geochemical paleoredox indicators in organic-rich shales: An example of the Lontras Shale Lagerstätte (Pennsylvanian-Permian, Paraná Basin, Southeastern Brazil)

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The determination of redox-sensitive trace elements (paleoredox proxies) in organic shales is a reliable parameter to define redox conditions for inferring the degree of oxygenation (oxic, suboxic, anoxic or euxinic conditions) of the water where these sediments were deposited. In this study, elemental analysis of U, Mo, Ni, V, Cu, Sr and Ba were determined in triplicate samples (LS03 and LS04 beds) collected of the organic shale Lontras (Pennsylvanian-Permian boundary, Paraná Basin, Southern Brazil). The results were obtained by an ELEMENTTM High-Resolution ICP-MS and express as $\mu\text{g.g}^{-1}$. LS03 sample (lower bed) is marked by the enrichment in U (av. 24.2) and V (av. 590.0) indicating anoxic bottom waters during deposition of the Lontras Shale. If enrichments in these elements are also coupled with high Ni (av. 89.03) and Cu (av. 73.06) contents, anoxia is accompanied by a high organic carbon sinking flux (high paleoproductivity). The deposition of the LS03 bed in fully anoxic (redox) conditions is corroborated by the high values of V/Ni e [V/Ni+V] ratios (680.36 and 0.87, respectively). On the other hand, lowest values of V/Ni e [V/Ni+V] ratios (361.43 and 0.75, respectively) in the LS04 indicate deposition on suboxic/anoxic conditions, verified also by the decrease in U (av. 7.76) and V (av. 270.3) contents related to the LS03 bed. It is observed that the V contents were always higher than the Ni contents, since the occurrence of marine organic matter favors the incorporation of V in relation to Ni. Sr/Ba ratio was similar for both beds indicating very low salinity (av. 0.185) (brackish conditions) during deposition of these shales in a shallow marine setting, supporting a nearshore setting. Moreover, Cu/Mo ratio of LS03 bed (5.48) suggests bottom-water anoxia driven by increased of organic flux (algal blooms?) while in the LS04 bed (4.91) the conditions were more suboxic/anoxic. In summary, trace elements are good paleoredox proxies for paleodepositional