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RADIOLYTIC EFFECTS IN ORGANIC MATTER – A BRIEF REVIEW

Radiolytic decomposition remains one of the major alternation processes affecting the organic matter closely associated with radioactive minerals. The interaction between ionizing radiation and an organic material result in the formation of activated species, ions, free radicals, and molecular species. The process is highly dependent on the composition of the organic matter and the nature of the environment, i.e., presence of water, the salinity of aqueous solutions, presence of oxygen (Colombo et al., 1964; IAEA, 1993). Thus, the reactions occurring during radiolytic processes are highly variable and the determination of a simple reaction mechanism remains difficult.

It has been established however, that the radiolytic processes are responsible for a dehydrogenation and an increase of the aromaticity of the radiolized material. In all experiments, molecular hydrogen represents more than 90% of the total gas yield (Kosiewicz, 1980; Lewan et al., 1991). The uraniferous organic matter tends to have relatively low solvent extract yield, low H/C atomic ratio, higher Rock-Eval T_{max}, increased hardness, increased reflectance and reveals variations in the carbon isotopic composition. Variations in the distribution of the hydrocarbons generated during pyrolysis have also been noticed when comparing mineralized and barren organic material from the same deposit (Leventhal and Threlkeld, 1978; Zumberge et al., 1981; Sassen, 1984; Forbes et al., 1988; Parnell, 1988; Landais, 1996).

Some studies have found that radiolysis can be responsible for oxidation of organic matter; organic matter with high uranium content has higher O/C ratios (Landais, 1993; Landais, 1996; Savary and Pagel, 1997). Kribek et al. (1999) observed, that the mineralized organic matter from the Pribram deposit was not oxygenized and both the H/C and O/C ratios proportionally decrease with increasing U content. The elevated oxidation stage can also result from the reduction of uranium and associated metals during the mineralizing process (Forbes et al., 1988; Cortial et al., 1990).

The most devastating effect of radiolysis in organic matter occurs in the spherical volume surrounding uranium-bearing minerals. Radiolytic alternation caused by high energy alpha particles is limited to a 50-100 μm high reflectance halo. This organic material is surrounded by darker organic material out of range of

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the alpha particles. Because the organic matter does not have a crystalline structure and because of the self-absorption of the nonpoint source of uranium mineral grain, a zone of radiation damage rather than discrete halos are seen (Leventhal et al., 1987; Eakin and Gize, 1992; Parnell, 1996; Gray et al., 1998) (Fig. 1). Highly mineralized samples from Poison Canyon Mine (Upper Jurassic Morisson Formation, New Mexico) reveal large coalescent areas of enhanced reflectance rather than isolated halos (Sassen, 1984).

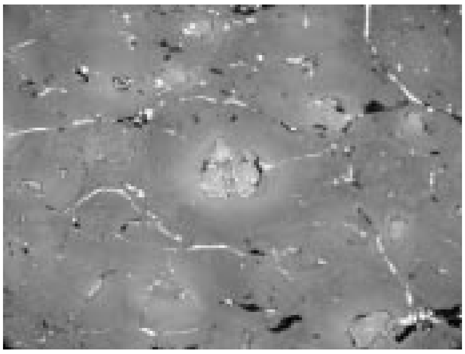

Fig. 1. High reflectance halo around uraninite grain (Carbon Leader seam, Witwatersrand) . Reflected light, one polar, magnification 500.

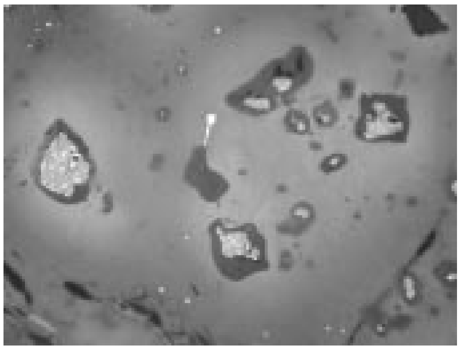

Fig. 2. An inner dark rim around uraninite grain (Carbon Leader seam, Witwatersrand). Reflected light, one polar, magnification 500.

The observation of radiation halos in electron images indicates that the halos differ chemically from the adjacent organic matter. X-ray maps indicate some dispersion of uranium into the halos, a stronger dispersion of lead, and in some cases an increased content of oxygen (Parnell, 1996). The infrared microspectroscopy reveals relatively decrease of the aliphatic CH band, relative increase of the aromatic C=C and C=O bands, and decrease of the aromatic CH bands within the high reflectance halos (Landais, 1996).

Some authors have observed additional narrow (ca 5 μm) inner isotropic rims of reduced reflectance (Leventhal et al., 1987; Gray et al., 1998). There have been also observed well-defined isotropic, dark halos in the Witwatersrand Carbon Leader seam (Fig. 2).

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