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Sodium storage in deep paleoweathering profiles beneath the Paleozoic-Triassic unconformity

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A major sodium accumulation has been recognized for long and by numerous authors in the Permo-Triassic salt deposits (Hay et al., 2006). Beside these basinal deposits, important masses of sodium were stored on the continents within deep palaeoweathering profiles in form of albite. Indeed, wide surfaces and huge volumes of granito-gneissic basements of the Hercynian massifs are albitized from North-Africa up to Scandinavia. These albitized rocks have usually been considered as related to tardi-magmatic metasomatic processes (Cathelineau 1986; Petersson and Eliasson 1997). Geometrical arrangement and dating of these alterations point out that these albitizations, or at least a part of them, developed under low temperature subsurface conditions in relation with the Triassic palaeosurface (Ricordel et al., 2007; Parcerisa et al., 2009).

Petrology

The albitized igneous rocks show a strong alteration with pseudomorphic replacement of the primary plagioclases into albite, replacement of primary biotite by chlorite and minor precipitation of neogenic minerals like albite, chlorite, apatite, haematite, calcite and titanite. Albitized rocks are characterized by their pink coloration due to the presence of minute haematite inclusions in the albite. The development and distribution of the albitization and related alterations above the unaltered basement occurs in three steps that define a vertical profile, up to 100-150 m depth.

1) In the lower part of the profile, albitization occurs within pink-colored patches in the unaltered rock, giving a pink-spotted aspect to the rock.

2) In the middle part of the profile, rocks have an overall pink coloration due to the albitization of the primary Ca-bearing igneous plagioclases. Usually, this facies develops in a pervasive manner, affecting the whole rock, but it may also be restricted to joints, giving a sharp-pink coloration to the fracture wall.

3) Finally, the top of the profile is defined by the same mineral paragenesis as in the pink stage, with an increase in the amount and size of sericite and hematite inclusions. The latter causes the red coloration of the altered rocks.

Regional layout

Regional distribution of the alterations which affect the Carboniferous igneous and volcanic formations beneath the Jurassic sedimentary cover lead to associate these alterations to the Triassic unconformity. Besides, albitized facies show generally both topographic and regional arrangements, with more altered facies occurring in the mountain highs and in the external parts of the massifs and unaltered facies occurring in the river valleys and in the central parts of the massifs. Moreover, the haematite associated with these albitized basement rocks has been dated from Early Trias by means of paleomagnetism (Ricordel et al, 2007). From this layout and dating, it is deduced that albitization is related to the development of a deep weathering profile (up to 150 m deep) during a long-lasting exposure of the Triassic erosional unconformity (regolith).

Geochemistry and paleoenvironmental setting

It has to be highlighted that, this alteration may not behave like an "ordinary" weathering profile and occurred under unusual, or at least very specific, geological settings. The scale of the profiles (over 100 m depth) relates this alteration rather to a groundwater environment. The weak mobility of most chemical elements may point to a groundwater with very low outflows and deep water table. This may occur in very subdued landscape and in arid climatic conditions. It has also to be pointed that this alteration may have lasted for several 10's of Ma.

Albite formation at low temperature may be envisioned consequently in alkaline, confined waters with sufficient concentrations of sodium and silica. Early attempts of modeling (Schmitt, 1994) have also indicated that a high Na+/K+ ratio is as well probably required. Petrographic data also indicate an import of sodium by the weathering solutions, without any clear enrichment in potassium. The Na+ enrichment is most likely linked with the peculiar geochemical setting of the Triassic environment where for instance halite moulds are very common in transgressive epicontinental deposits. The leaching of such salts, the role of salty marine aerosols, or a periodic/episodic contribution of seawater or evaporative solutions may be equally invoked.

Mass balance

Taking into account the surpergene origin of albitization and its widespread development on the Paleozoic basement rocks (from Morocco to Scandinavia) means that high amounts of Na+ have been stored in the deep paleoweathering profiles of the Triassic continents. This sodium storage in weathering profiles has to be taken in consideration in addition to the major sodium chloride accumulation in the basins during the Permo-Triassic times. Further investigations are needed to demonstrate the extent of these paleoweathering profiles and then to estimate the amount of this continental sodium storage.

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