

Geological development of Ruprechtov site

Within the bilateral co-operation project NATAN (NATural ANalogue) the Ruprechtov site (near Karlovy Vary, CZ) is being investigated by GRS and the Czech Nuclear Research Institute (NRI) in order to identify the main mobilisation resp. immobilisation processes of uranium which are relevant for performance assessment. The site was chosen because its geological and geochemical conditions are similar to sedimentary sequences covering potential host rocks for deep geological disposal of radioactive wastes. To understand the processes it is essential to know the site's geological history.

The following sequence of sketches summarises the ideas of the development of the Ruprechtov site as shown in the animation. Its aim is to represent single important steps that led to the current geometry of rock units and to the development of the uranium mineralisation style.

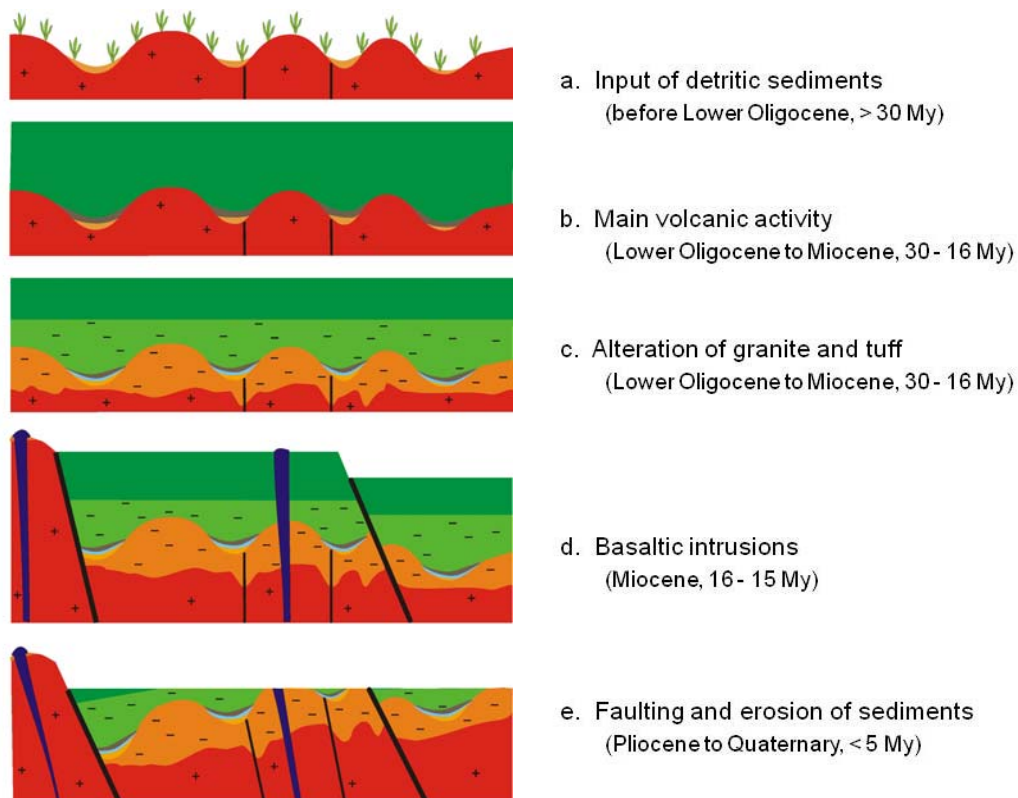


Figure Sketch sequence of geological development of Ruprechtov site (for detailed explanations see text; My = million years) – not to scale

a. Input of detritic sediments (before Lower Oligocene, >30 My)

During this period the old pre-Tertiary landscape is dominated by a granitic inselberg structure (red) with hills and valleys. Few older faults are present. The landscape is covered by vegetation - grass, trees and swamps dominate the valleys. Input of clastic material (light brown) including detritic uranium minerals occurred by rubble slope and/or short distance alluvial transport forming thin clayey-sandy layers with limited thickness in the range of app. 1 m. The amount of uranium phases of detritic origin today accounts for max. 10 % of the whole uranium content in these layers.

b. Main volcanic activity (Lower Oligocene to Miocene, 30 - 16 My)

This period was characterized by strong volcanic and also tectonic activity. The granites were covered by volcanic ashes (tuff - green). The estimated thickness of the ash fall at Ruprechtov is approximately 200 m. Temperature of the groundwater and sediments was slightly elevated at that time. The volcanic ashes destroyed the vegetation leading to sedimentation of organic matter (dark brown) at the bottom of the volcanic ash horizon. This organic matter is preferably accumulated in valleys.

c. Alteration of granite and tuff (Lower Oligocene to Miocene, 30 - 16 My)

Certainly, a large amount of mantle CO₂ was released by the volcanic activity and trapped, probably together with oxygen, in the volcanic ashes deposited. It is very likely that additionally CO₂ poured out from fault zones. These processes caused CO₂-rich waters, which were able to strongly alter the volcanic material and the underlying granite, which is schematically shown in the following figure (= detail of step c).

By bentonitisation of the tuffites (light green), clay minerals were formed. Alteration of the underlying granite mainly occurred by reaction of feldspars with CO₂ rich water and formation of kaolinite (orange). The CO₂ rich water could also initiate uranium release from accessory minerals by formation of soluble UO₂ carbonate complexes. Transport through kaolin layers occurred mainly by diffusion. At the interface of kaolin and pyroclastic sediments higher hydraulic conductivity could have enhanced advective transport of uranium released from the kaolin. Uranium accumulation (light blue) then occurred in the clayey-sandy sediments by sorption on organic matter (already altered to lignite) as well as by reduction to Uranium(IV) and precipitation of phosphorous bearing minerals.

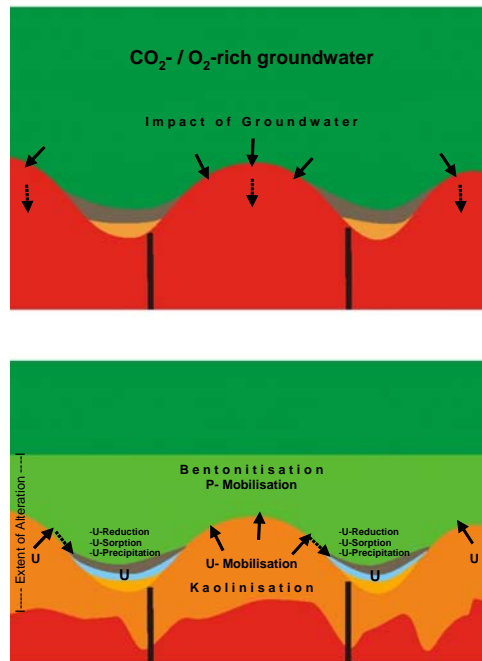


Figure Schematic picture of alteration processes in granite and tuffitic sediments (detail of step c)

d. Basaltic intrusions (Miocene, 16 - 15 My)

Basaltic intrusions (dark blue) into the tertiary sediments occurred at approximately 16 - 15 My ago and lead to contact metamorphism of the already bentonitised, resp. kaolinised surrounding rocks. In addition, elevated temperatures could also have caused convective groundwater flow conditions boosting uranium release from deeper parts of granite. Today the major amount of uranium (light blue) is accumulated in the clay-sand-lignite layers due to sorption processes and/or reduction from uranium(VI) to uranium(IV), prevailed in places of thin and/or absent underlying kaolin. A special argument for the important role of basaltic intrusions in uranium migration is the fact that highest uranium concentrations are found in Ruprechtov as well as the nearby Hajek site, where occurrence of basaltic intrusions are by far strongest. Especially at Hajek uranium concentrations were that high that it was mined for some period after 1960.

e. Faulting and erosion of sediments (Pliocene to Quaternary, < 5 My)

The whole area was tilted in the normal faulting (black lines) as a consequence of the crustal stretching and important erosion removed larger parts of volcanic strata (tuff). The deepest part of the basin (140 m) today is close to main Erzgebirge fault.