Talk Ok 2.2

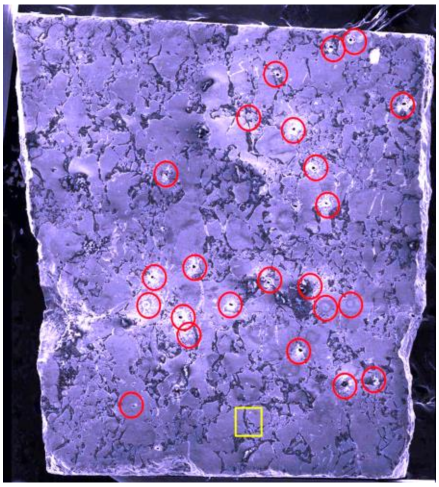
Natural Nuclear Reactors: prediction, search, discovery, operation and implications

Alex MESHIK[1*]***, Olga PRAVDIVTSEVA***[1] ***and Evan GROOPMAN***[2]

[1] Physics Department and McDonnell Center for Space Sciences, Washington University,
[1] Brookings Drive, Saint Louis, MO 63130, USA,
[2] Materials Measurement Science Division, National Institute of Standards and Technology, Gaithersburg, MD, 20899, USA

Email: ameshik@physics.wustl.edu

Natural nuclear reactors operated in Oklo (Gabon) about 2.0 billion years ago [1]. This phenomenon was predicted and led to a systematic search for uranium deposits that went critical. Fifty years ago, just a few years after this search was abandonded, the Oklo phenome-non was discovered by chance. Many elements extracted from the Oklo reactor material still carry clear isotopic signatures of ^{235}U fission, ^{239}Pu production and neutron capture reactions. Isotopic compositions of these elements provided reconstruction of neutron fluence, amount of consumed ^{235}U, and an effective duration of nuclear fission chain reaction that was estimated to last for hundreds of thousands of years [2]. It was not clear, however, whether the reactor was operating continuously or in pulses. One proposed mechanism was based on burning up highly neutron absorbing impurities (RRE and/or boron) [3]. As the strong absorbers were burned up at one edge of the reactor zone and uranium at the other one, the active zone could have shifted along the U-vein making different parts of the natural reactor been active at different times [3]. Another potential self-regulation mechanism could have involved water acted as a neutron moderator. As the temperature of the reactor increases, all unbounded water was converted into steam, reducing neutron thermalisation and shuting down the chain reaction. Only when the reactor cooled down and the water concentration increases again, could the chain reaction resume. A tiny sample from reactor zone RZ-13 kindly provided by Maurice Pagel, Philippe Holliger and François Gauthier Lafaye carried the answer to this and several other questions.



Novel analytical techniques LENGA and NAUTILUS used for analyses of this 4×3 mm slab revealed:

* the highest concentration (~8´10^{17} atom/g) of fission Xe ever observed in natural materials [4]
* cycling operation of RZ-13 of Oklo and self-regulating mechanism [5],
* lowest ^{235}U/^{238}U = 0.3655 and capture of fission Cs and Ba 5 yr. after the shutdown [6] ,
* Al-phosphates and metallic aggregates preserve certain fission products over a geologic time [4, 7].

(Red circles show craters made by LENGA = Laser Extraction Noble Gas Analyses. Yellow square shows area studied by NAUTILUS = NAval Ultra-Trace Isotope Laboratory's Universal Spectrometer, the US Naval Research Laboratory).

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