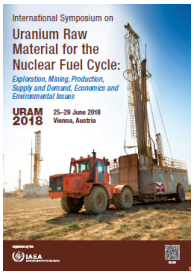

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Geological samples pinpoint for nuclear forensics examination in Thailand

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INTRODUCTION

Nuclear forensics laboratory was established in 2013 at Office of Atoms for Peace (OAP), Ministry of Science and Technology, Thailand [1]. One of the purposes is to collect the data of uranium and thorium resources in Thailand. Thus, we signed up Memorandum of Understand (MOU) among Department of mineral resources (DMR), Ministry of Natural Resources and Environment and Thailand Institute of Nuclear Technology (TINT), Ministry of Science and Technology. The purposes of the MOU are incorporate and information sharing about rare-earth elements (REE), Naturally Occurring Radioactive Material (NORM); knowledge management for mineral resources; NORM monitoring; develop national nuclear forensics database ; and develop REE and nuclear materials determination techniques [2].

Uranium (U), thorium (Th) and other rare-earth elements (REE) which are occurred with monazite ore, was surveyed by DMR. The results show that U, Th and REE are mutually associated with Tin and wolfram minerals, while REE occurs in the form of phosphate mineral. In early 1970's, the geologist discovered of REE and other heavy minerals in significant amount as secondary deposits and alluvial with tin deposits in southern part of Thailand [3]. In 1980's DMR corporated with Japan International Cooperation Agency (JICA) examined REE mineral deposits in northern part of Thailand. The highest REE contents which found in the southern part of Thailand which contents 0.092% [4]. In 2014, Kritsananuwat, R., et al. studied for the amount of REE, Th and U concentration in marine sediments along the Gulf of Thailand, they found the group of correlation between the source and type of elements [5].

In the present, there are several techniques to identify the major and trace element in geological samples. The data from many analytical methods can be used for nuclear forensics aspect. It is meant that scientists look after the nuclear forensics signatures from geological samples. Nuclear forensics is the procedure for determine the origin of radioactive materials, nuclear materials and contaminated evidences. Nuclear forensic laboratory can afford the analysis samples in order to identify material types, manufacturing company, and fabrication process in terms of support the investigation. [6].

Mary Kathleen mine, uranium mine in Australia, is a classical case study for combined nuclear forensics capabilities with mining resources [7]. This study compared the uranium and other trace elements concentration with the several sources, by using 13 characterization techniques.

DESCRIPTION

DMR collected geological samples from the Southern part of Thailand. After Nuclear Forensic Laboratory received 150 grinded geological samples from DMR. The samples were labeled, dried in an oven at 110 ☒C for 3 hours, grinded, then they were keep in desiccators and room temperature. Nuclear forensics scientists examined the samples by using non-destructive analysis (NDA) and destructive analysis techniques.

Characterization of samples

The samples have 3 colors: light gray, brown and red. The samples were well-mixed or homogenized. We found that samples in the same area would be in the difference colors.

For NDA techniques, we used 4 techniques:

• Scanning Electron Microscope with Energy Dispersive Spectrometry (SEM/EDS) from Vega3 LMU (TESCAN, Brno Czech Republic) was examined surface and microstructure [5] of soil samples for magnification 13x up to 1,000,000x. We found that the heavy elements especially uranium, thorium and REE will be brighter than the other elements in back-scattering mode. Thus, SEM would be used to examine in geological samples which they have small amount of signature elements.
• X-ray diffraction (XRD) with D2 Phaser (Bruker AXS GmbH, Germany) was used to study the crystal structures. We found 2 major crystal structures: quartz (SiO_2) and microcline ($KAlSi_2O_3$) that have Silicon dioxide (SiO_2) or quartz, Aluminium oxide (Al_2O_3) component.
• X-ray fluorescence (XRF) by S1 TITAN (Bruker AXS GmbH, Germany) was identified the major elements in samples. Silicon dioxide (SiO_2), Aluminium oxide (Al_2O_3) and Iron oxide (Fe_2O_3) are the major component of samples, respectively.
• High Purity Germanium detector (HPGe) for Gamma Spectrometry (ORTEC Gem Series, USA) was used to measured radioactive material in samples. The samples were packed in wide-mouth bottle, around 150 grams per samples. The measurement time was 10,000 second per sample. We found natural radioactivity in samples such as potassium-40, thorium-232 and uranium-238. The variation of radionuclide components in the sample would be determined the distribution of geological source [8].

For DA method, we used Inductively Coupled Plasma –Mass Spectrometry (ICP-MS) from Agilent 7700x (Agilent, Japan). The samples were prepared to be a solution by using fluxer (K1 Prime Katanax, inc., Canada) which added some lithium borate fluxes. Then, the samples were determined major elements and trace elements (detection limit in part per billion) which were supported for nuclear forensics investigation. Because it is an accuracy techniques and it can be segregated small amount concentrations which gives information of the mining and/or rare earth ore processing [9].

DISCUSSION AND CONCLUSION

The amount of several elements in geological samples can be identified source of origin. In this study, we found that the trace elements and REE are the signature of samples. The XRD spectra show that they would be quartz and microcline. Due to the samples are from many provinces in southern part of Thailand. It can be assumed that we can use the mineral resources (included uranium, thorium, REE and other trace elements) as the one of the nuclear forensics database in order to pinpoint the global positioning system (GPS) and compare to unknown sample location.

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