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GrayQb™ Single-Faced Version 2 (SF2) Hanford Plutonium Reclamation Facility Radiological Examination

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INTRODUCTION

The Savannah River National Laboratory (SRNL) in partnership with CH2M Plateau Remediation Company deployed the GrayQb™ Single-Faced Version 2 (SF2) radiation imaging device at the Hanford Plutonium Reclamation Facility (PRF) to assist in the radiological characterization of the canyon. The deployment goal was to locate radiological contamination hot spots in the PRF canyon where most of the pencil tanks had been removed and decontamination/debris removal operations were on-going, to support the CH2M facility decontamination and decommissioning (D&D) effort.

DESCRIPTION OF THE ACTUAL WORK

GrayQb™ SF2 Radiation Mapping Device

The GrayQb™ SF2 (Single Faced Version 2) is a non-destructive examination (NDE) device developed by SRNL to generate radiation contour maps showing source locations and relative radiological levels present in the area under examination (Figure 1). The GrayQb™ SF2 is a passive radiation mapping device composed of a custom tungsten shield, digital camera and a radiosensitive Phosphor Storage Plate (PSP).

Development of the GrayQb™ SF2 radiation mapping device began from a need to identify radiation locations to aid in the process of D&D efforts. The goal of the GrayQb™ (pronounced "Gray Cube") device was to provide a low cost, easily deployable device that would provide results to users in a short period of time. Devices and technologies are presently available which provide radiation detection; subsets of these systems also provide mapping of detected source locations onto a photo. Advantages of the GrayQb™ device over these other devices include its relative low cost (<$7k to manufacture), small size (6" cube) and no required wired connections when deployed (Figure 1). The low cost of GrayQb™ makes it feasible to deploy multiple devices at one time and to dispose of the device without significant financial loss should it become contaminated. The small size and low weight of the GrayQb™ device allow for deployments in areas not accessible by many other radiation detectors. Additionally, the GrayQb™ device can be easily carried and deployed on a tabletop or tripod with optional internal shielding in place (Figure 2).

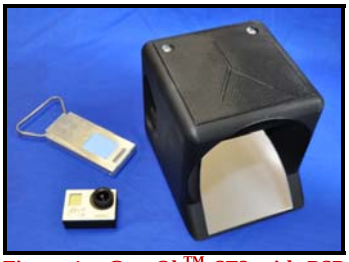

Figure 1 - GrayQb™ SF2 with PSP holder & internal camera

Figure 2 - GrayQb™ devices deployed using tripods

Deployment Preparation

The Hanford PRF canyon GrayQb™ deployment was performed using the overhead crane to position and hold the devices for the surface examinations (Figure 3). For the purposes of this deployment, a crane fixture was designed and fabricated at SRNL that held four devices enabling four examinations to be performed during each deployment.

Figure 3 - PRF GrayQb deployment using overhead crane

The SRNL 3D Visualization System was used to determine the minimum number of deployments required to examine the canyon surfaces given the field of view (FOV) of the GrayQb™ device (Figure 4). By importing the PRF canyon drawings and the GrayQb™ device design files into the 3D system, the device FOV could be projected onto the canyon surfaces and virtually moved about in the canyon to determine required placement for complete coverage. It was determined that all surfaces (walls, floor and ceiling) could be examined with ten deployments which would provide forty GrayQb™ examinations.

Figure 4 - 3D Imaging Technology showing GrayQb™ FOV on canyon walls for deployment planning

Canyon Deployment

The PRF canyon GrayQb™ deployment was performed September 7 - 12, 2015. Ten deployments consisting of a cluster of four devices mounted on the crane platform fixture were completed providing forty examinations. GrayQb™ devices where bagged by radcon operators in a clean maintenance area near the canyon and passed to PRF operators in the step off area to be installed onto the crane fixture for deployment. Once the device cluster was deployed in the canyon, the devices were retrieved by the PRF operators at the canyon entrance and passed to radcon operators for survey prior to being released to the clean area for processing, Figure 5. The device results were processed in the maintenance area as described in the next section. Preliminary resultant images were provided to CH2M immediately at the test site.

Figure 5 - GrayQb™ undergoing radiological survey

Processing of Results

The GrayQb™ suite of equipment includes the GrayQb™ device(s), PSP scanner, PSP pre-illuminator and laptop. The suite is highly portable and can be easily set up at a test location to process results on-site, Figure 6.

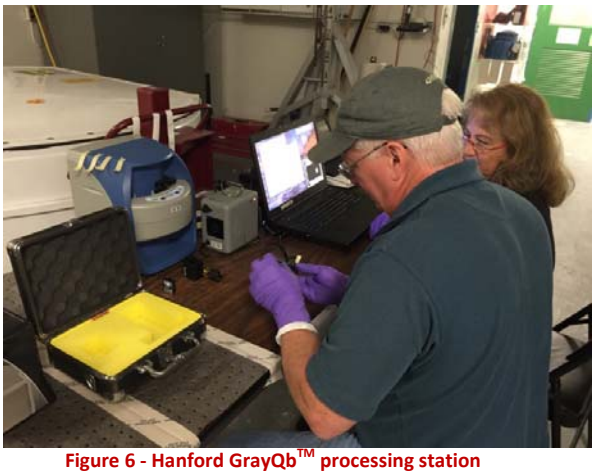

Figure 6 - Hanford GrayQb™ processing station

Preparation of the GrayQb™ for deployment requires that the device be initially configured with a PSP plate pre-illuminated for 10 seconds, a GoPro camera with charged battery, and optional internal shielding. Once prepared, the device is deployed for a predetermined amount of time based on expected dose and energy level of expected isotopes; for the PRF this was initially estimated to be 8 hours for each deployment.

After retrieving the device, the PSP which captures the gamma image, is removed from the device, scanned and imported to a laptop (Figure 7). The camera is also retrieved from the device and it's digital images imported onto the computer. Imported images are processed using the SRNL developed Radiation Analyzer (RAzer™) software program. RAzer™ generates the radiation contour maps from the PSP image and superimposes the results onto the digital image of the area under examination.

Once the GrayQb™ SF2 is retrieved from the area under examination, processing of the images and obtaining a result takes only a few minutes.

Figure 7 - PSP plate is scanned after deployment and imported to RAzer™ program on laptop for processing

GrayQb™ Results Post Processing

Post processing of the data was performed to validate preliminary information provided to CH2M and to analyze the data for distribution tendencies, conclusions and to enhance the overall usefulness by normalizing data for time and distance and providing summary views.

Post processing began with the adjustment of each PSP gamma image to correct for PSP misalignment into the scanner. The PSP rarely feeds into the scanner at exactly a 90 degree angle; for post processing each raw PSP image was viewed and rotated, if required, to correct for any PSP scanning misalignment. The greatest angle of correction was less than 3%. Post processing continued with the removal of the fish eye effect from the digital image. Final post processing activities included: Removing outlier pixels from the raw gamma image, applying an intensity correction which adjusted for the drop in PSP sensitivity as the angle of exposure increases and finally normalizing the gamma intensities for deployment time and distance.

To highlight hot spots in the results, a Fast Fourier Transform (FFT) algorithm was applied to the post processed results.

Final Results

Canyon deployment 3 (D3) and deployment 4 (D4) were unintentionally performed at nearly the same location which resulted in a small loss of canyon surface examination but provided very useful information. First, the duplicate examination of the same location was performed using two different GrayQb™ devices which produced results that were almost identical, this demonstrated the repeatability of the results using the device, Figure 8. Secondly, the two data sets provided a validation for the application of the post processing methodologies. D3 lasted 6.5 hours and D4 lasted 15 hours, after completing post processing adjustments including time normalization, the results demonstrated similar intensities. After applying the hot spot algorithm to the post processed data, D3 and D4 identified the same hot spots.

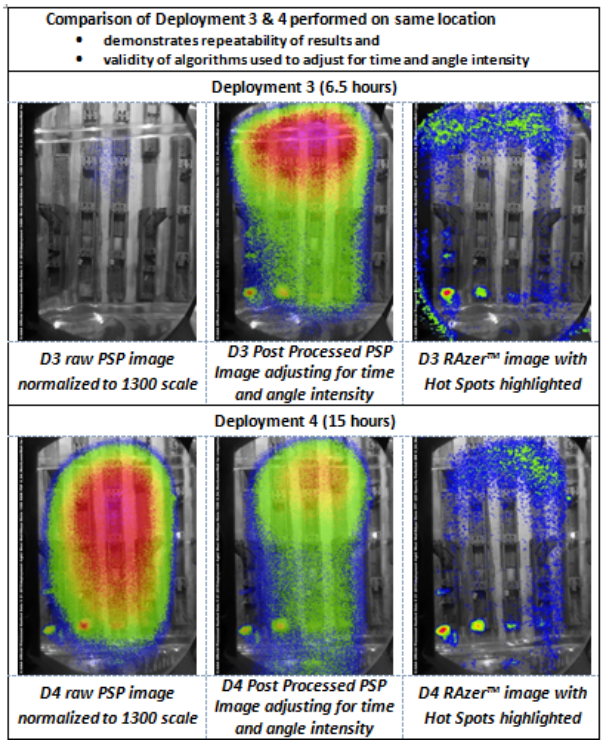

Figure 8 - Comparison of Deployments 3 and 4 analyzing the same location

Hot Spot Montages

Montage views were created of the east wall, the west wall and the floor showing locations of hot spots to provide CH2M a singular cohesive view of these surfaces (Figure 9). The montage views were created by hand overlaying RAzer™ results onto stitched deployment photos.

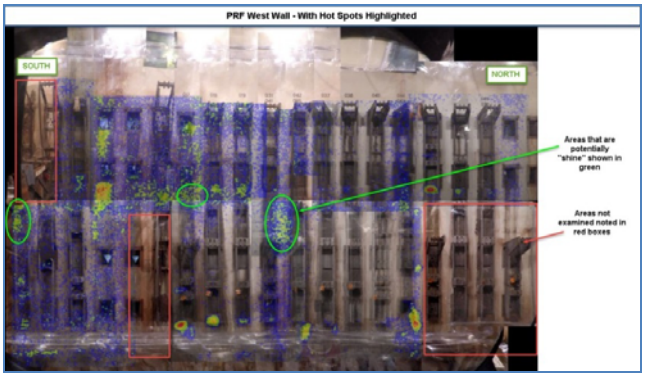

Figure 9 - Montage view of PRF West Canyon Wall

Hot spot colors on the individual RAzer™ results do not necessarily indicate equal intensities between results; when creating the montage hot spot maps, in those cases where deployment results overlapped and the same hot spot could be seen in two different views, the colors were made to be of equal color to help delineate relative intensity between

the views (Figure 10). Many, but not all, deployments had overlapping hot spots.

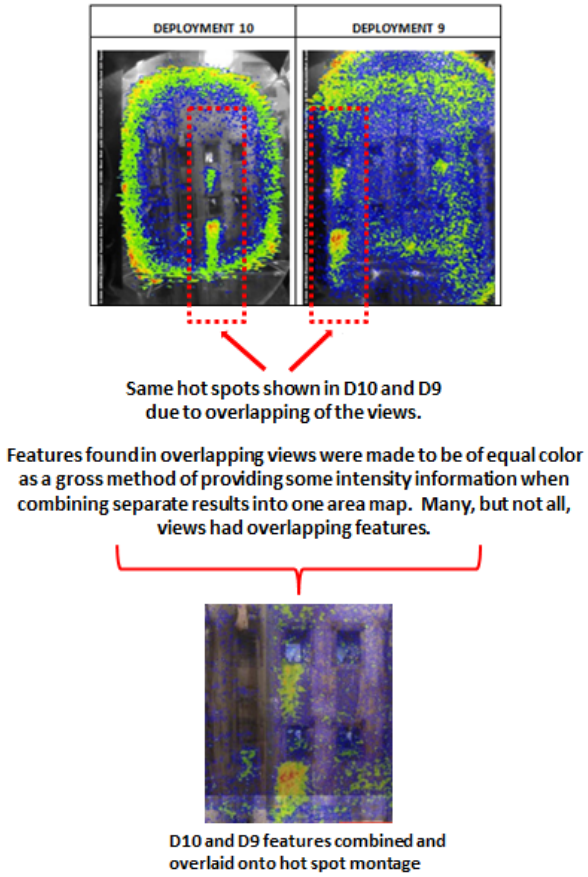

Figure 10 - Discussion of Hot Spot montage colors

Interesting features to note on the floor montage shown in Figure 11 include the high intensity circled spot at the left of the photo which shows a floor pan that has not yet been cleaned. Also interesting is the floor to the right of the red rectangle which been cleaned but latent contamination can be seen along the corners of the floor pans where it is so difficult to thoroughly access for cleaning. Note that the radiation intensity of the uncleaned pan to the right is much higher than the cleaned area, however for this montage the two areas were not normalized with each other as the cleaned area spots would disappear.

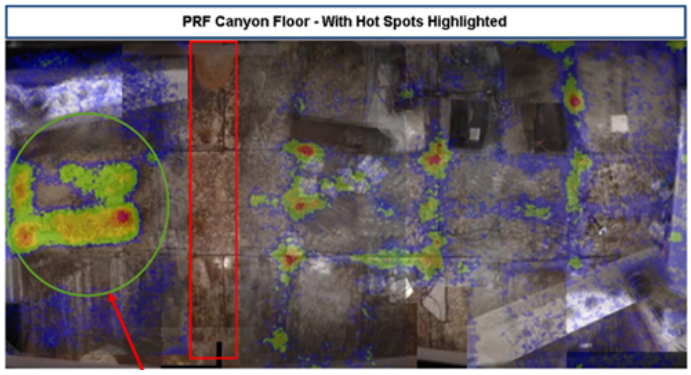

Figure 11 - Montage view of the PRF canyon floor

CONCLUSION

The GrayQb™ proved to be a useful tool in the radiological characterization of the Hanford PRF canyon. Patterns in contamination were identified providing information to assist in more efficient planning of the D&D effort. Hot spots were identified which could be targeted during the future D&D effort and used as markers during the NDA assessment to quantify the radiological environment. *"The GrayQb images of the canyon walls continue to be useful in our decontamination efforts"* – CH2M.

ACKNOWLEDGMENTS

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