**Appendix A**

*Virtual Outcrop Modelling and fracture volumetrics*

The orthorectified model shown in Figure 6a was generated using Agisoft’s Photoscan which implements structure from motion photogrammetry. In total 215 images were acquired via UAV and processed. Images were captured in scan lines at a variety of orientations and altitudes to enhance data capture from obscure angles. Once the 3D model was generated the 2D map-view data could be extracted to form an orthorectified image – a high resolution georeferenced image map. This map was then input into Adobe Illustrator where 4362 traces, 14129 segments, and 18491 nodes of fractures were mapped using vector graphics. Once mapped the interpreted fracture traces and fault wall interfaces were exported as a georeferenced image and interpreted manually using sample windows and in bulk using the MatLab extension FracPaQ for QA/QC purposes.

In addition to the 1D fracture traces mapped, sample areas were interpreted areally, distinguishing between the red fault-void sedimentary infills, and the blue/grey limestone host rock. In doing so a two-tone image was generated defining regions by colour as either “fracture fill - red” or “basement - blue”. The two-tone image was input into the image processing toolbox of MatLab, which calculated the total number of pixels and the number of red and blue pixels for the sample area. Whereby each pixel forms a cell of fixed area, with the same resolution as the original image.

*I = imread(uigetfile);*

*redPixels = I(:,:,1) == 255 & I(:,:,2) == 0 & I(:,:,3) == 0;*

*numRedPixels = sum(redPixels(:));*

*bluePixels = I(:,:,1) == 0 & I(:,:,2) == 0 & I(:,:,3) == 255;*

*numBluePixels = sum(bluePixels(:));*

*B = numBluePixels;*

*R = numRedPixels;*

*A = B+R;*

Once the numbers of each pixel colour were determined; the ratio between them was calculated to give a percentage value for fracture fill.

*pB = (B/A)\*100;*

*pR = (R/A)\*100;*

*pA = pB + pR;*

*TPC = ['Total Pixel Count = ',num2str(A)];*

*FFP = ['Fracture Fill Pixels = ',num2str(R)];*

*BP = ['Basement Pixels = ',num2str(B)];*

*PL = ['Percentage Basement = ',num2str(pB)];*

*PS = ['Percentage Fracture Fill = ',num2str(pR)];*

*ACC = ['Accuracy /100 = ',num2str(pA)];*

*disp(TPC)*

*disp(FFP)*

*disp(BP)*

*disp(PL)*

*disp(PS)*

*disp(ACC)*

In addition to the analyses described in the present paper, if the area of each pixel can be determined these can be input to generate areas in m2. Which gives an accurate regional assessment of the area covered by fracture fill in 2D for the given sample area.

prompt = {'Pixel Area /m^2'};

title = 'Scaling Input';

dims = [1 35];

definput = {'0.00005'};

PixelArea = inputdlg(prompt,title,dims,definput);

Once 2D areas are calculated using this method, the analysis can be tentatively expanded into the third dimension as a thought experiment to estimate the potential fluid volumes the host rock could hold. Given the regional assessments of Tor Bay, particularly around Berry Head – it is highly likely that these filled fractures/fissures extend to at least 1km in depth. The sandstones filling these fissures are also highly porous ,well-sorted rounded grains making them ideal hydrocarbon reservoir rocks. If we assume a depth of around 1km to a fixed point, good reservoir properties (35-40% porosity, 50% water saturation), and an arbitrary formation volume factor (can be altered for analogue of any depth), we can assess what volume of hydrocarbons or any fluid the sample area could possibly hold per gross rock volume using the HCIIP or STOIIP equations.

XA = str2double(PixelArea);

GRA = XA\*A;

Gross = ['Gross Rock Area = ',num2str(GRA),'m^2'];

disp(Gross)

prompt = {'Height of Hydrocarbon Column /m', 'Average Porosity', 'Average Hydrocarbon Saturation', 'Formation Volume Factor'};

title = 'Input Parameters';

dims = [1 35];

definput = {'250', '0.37', '0.5', '1.5'};

Answers = inputdlg(prompt,title,dims,definput);

h = str2double(Answers{1,1});

Por = str2double(Answers{2,1});

HCsat = str2double(Answers{3,1});

FVF = str2double(Answers{4,1});

GRV = GRA\*h;

NTG = (pR/100);

NRV = GRV .\* NTG;

NPV = NRV .\* Por;

HCPV = NPV .\* HCsat;

HCIIP = HCPV / FVF;

HCIIPb = (HCIIP \* 6.289814)/100000;

HCdisp = ['HCIIP = ', num2str(HCIIP),'m^3',];

HCdisp = [HCdisp newline 'HCIIP = ', num2str(HCIIPb),'MMbbls'];

GRVdisp = ['Gross Rock Volume = ', num2str(GRV), 'm^3'];

disp(GRVdisp)

disp(HCdisp)