APPENDIX 20d

CLASSIFICATION AND REGRESSION TREE (CART) SENSITIVITY ANALYSIS
PREDICTING
EXPECTED EGS FAVORABLE CELLS USING WELL DATA

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1. INTRODUCTION

This analysis was performed to understand the predictive powers and relationships between eight key geoscience parameters using CART. This statistical method was utilized using *RStudio*, a publically available user interface for performing various statistics. See www.rstudio.com for more information.

The following series of tables document the CART sensitivity analysis exploring all possibilities of the indicated parameters (Table 20d.1) for predicting expected EGS favorable cells. A total of eight parameters were used as explanatory variables and listed in the table below. The analysis explored every possible combination from eight variables considered to only one variable considered. The results are organized by the number of variables used in the analysis from eight to one, and are reported from the highest to lowest r^2-values (Tables 20d.2 to 20d.9). Selected analyses that are significant are bolded. The explanatory variables used in the analysis are listed in column 1. The number of variables used can be found in column 2. Whether the parameter vertical stress, considered a surrogate for depth that could be influencing the analysis, was used in the analysis is shown in column 3. The resulting r^2-value can be found in column 4.

Table 20d.1. Explanatory Variables used in the CART Sensitivity Analysis.

Notation	Parameter Description
MTemp	Temperature
VS	Vertical Stress
VPS	Seismic parameter: p-wave velocity
Lith	Lithology type
Fault	Presense of Absence of a Fault
MT	Resistivity derived from the Magnetotellurics
CSC	Modeled Stress parameter: Coulomb Stress Change
Dil	Modeled Stress parameter: Dilatational Strain

Table 20d.2. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with eight variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
MTemp,VPS,CSC,MT,Dil,Fault,VS,Lith	8	X	0.708

Table 20d.3. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with seven variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
MTemp,VPS,CSC,MT,Dil,Fault,VS	7	X	0.727
MTemp,VPS,CSC,MT,Dil,Fault,Lith	7		0.708
MTemp,VPS,CSC,MT,Dil,VS,Lith	7	X	0.708
MTemp,VPS,CSC,Dil,Fault,VS,Lith	7	X	0.708
MTemp,VPS,MT,Dil,Fault,VS,Lith	7	X	0.708
MTemp,CSC,MT,Dil,Fault,VS,Lith	7	X	0.708
VPS,CSC,MT,Dil,Fault,VS,Lith	7	X	0.661
MTemp,VPS,CSC,MT,Fault,VS,Lith	7	X	0.523

Table 20d.4. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with six variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
MTemp,VPS,CSC,MT,Dil,Fault	6		0.769
MTemp,VPS,CSC,MT,Dil,VS	6	X	0.727
MTemp,VPS,CSC,Dil,Fault,VS	6	X	0.727
MTemp,VPS,MT,Dil,Fault,VS	6	X	0.727
MTemp,CSC,MT,Dil,Fault,VS	6	X	0.727
MTemp,VPS,CSC,MT,Dil,Lith	6		0.708
MTemp,VPS,CSC,Dil,Fault,Lith	6		0.708
MTemp,VPS,CSC,Dil,VS,Lith	6	X	0.708
MTemp,VPS,MT,Dil,Fault,Lith	6		0.708
MTemp,VPS,MT,Dil,VS,Lith	6	X	0.708
MTemp,VPS,Dil,Fault,VS,Lith	6	X	0.708
MTemp,CSC,MT,Dil,Fault,Lith	6	X	0.708
MTemp,CSC,MT,Dil,VS,Lith	6	X	0.708
MTemp,CSC,Dil,Fault,VS,Lith	6		0.708
MTemp,MT,Dil,Fault,VS,Lith	6	X	0.708
VPS,CSC,MT,Dil,Fault,Lith	6		0.708
VPS,CSC,MT,Dil,VS,Lith	6	X	0.661
VPS,CSC,Dil,Fault,VS,Lith	6	X	0.661
VPS,MT,Dil,Fault,VS,Lith	6	X	0.661
CSC,MT,Dil,Fault,VS,Lith	6	X	0.661
VPS,CSC,MT,Dil,Fault,VS	6	X	0.637
MTemp,VPS,CSC,MT,Fault,VS	6	X	0.578
MTemp,VPS,CSC,MT,VS,Lith	6	X	0.523
MTemp,VPS,CSC,Fault,VS,Lith	6	X	0.523
MTemp,CSC,MT,Fault,VS,Lith	6	X	0.523
VPS,CSC,MT,Fault,VS,Lith	6	X	0.511
MTemp,VPS,CSC,MT,Fault,Lith	6		0.504
MTemp,VPS,MT,Fault,VS,Lith	6	X	0.409

Table 20d.5. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with five variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
MTemp,VPS,CSC,MT,Dil	5		0.769
MTemp,VPS,CSC,Dil,Fault	5		0.769
MTemp,VPS,CSC,Dil,VS	5	X	0.727
MTemp,VPS,MT,Dil,VS	5	X	0.727
MTemp,CSC,MT,Dil,VS	5	X	0.727
MTemp,CSC,Dil,Fault,VS	5	X	0.727
MTemp,MT,Dil,Fault,VS	5	X	0.727
MTemp,VPS,CSC,Dil,Lith	5		0.708
MTemp,VPS,MT,Dil,Lith	5		0.708
MTemp,VPS,Dil,Fault,Lith	5		0.708
MTemp,VPS,Dil,VS,Lith	5	X	0.708
MTemp,CSC,MT,Dil,Lith	5		0.708
MTemp,CSC,Dil,Fault,Lith	5		0.708
MTemp,CSC,Dil,VS,Lith	5	X	0.708
MTemp,MT,Dil,Fault,Lith	5		0.708
MTemp,MT,Dil,VS,Lith	5	X	0.708
MTemp,Dil,Fault,VS,Lith	5	X	0.708
VPS,CSC,MT,Dil,Lith	5		0.708
VPS,CSC,Dil,Fault,Lith	5		0.708
VPS,MT,Dil,Fault,Lith	5		0.708
CSC,MT,Dil,Fault,Lith	5		0.708
MTemp,CSC,MT,Dil,Fault	5		0.690
VPS,CSC,Dil,VS,Lith	5	X	0.661
VPS,MT,Dil,VS,Lith	5	X	0.661
VPS,Dil,Fault,VS,Lith	5	X	0.661
CSC,MT,Dil,VS,Lith	5	X	0.661
CSC,Dil,Fault,VS,Lith	5	X	0.661
MT,Dil,Fault,VS,Lith	5	X	0.661
VPS,CSC,MT,Dil,VS	5	X	0.637
VPS,CSC,Dil,Fault,VS	5	X	0.637
VPS,MT,Dil,Fault,VS	5	X	0.637
CSC,MT,Dil,Fault,VS	5	X	0.637
MTemp,VPS,CSC,MT,Fault	5		0.619
MTemp,VPS,MT,Dil,Fault	5		0.579
MTemp,VPS,CSC,Fault,VS	5	X	0.578
MTemp,CSC,MT,Fault,VS	5	X	0.578
VPS,CSC,MT,Dil,Fault	5		0.547
MTemp,VPS,CSC,VS,Lith	5	X	0.523
MTemp,CSC,MT,VS,Lith	5	X	0.523
MTemp,CSC,Fault,VS,Lith	5	X	0.523
MTemp,VPS,MT,Fault,VS	5	X	0.517
VPS,CSC,MT,VS,Lith	5	X	0.511

Table 20d.5. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with five variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
VPS,CSC,Fault,VS,Lith	5	X	0.511
CSC,MT,Fault,VS,Lith	5	X	0.511
MTemp,VPS,CSC,MT,Lith	5		0.504
MTemp,VPS,CSC,Fault,Lith	5		0.504
MTemp,CSC,MT,Fault,Lith	5		0.504
VPS,CSC,MT,Fault,Lith	5		0.480
VPS,CSC,MT,Fault,VS	5	X	0.477
MTemp,VPS,MT,Fault,Lith	5		0.425
MTemp,VPS,MT,VS,Lith	5	X	0.409
MTemp,VPS,Fault,VS,Lith	5	X	0.409
MTemp,MT,Fault,VS,Lith	**5**	**X**	**0.409**
VPS,MT,Fault,VS,Lith	5	X	0.383

Table 20d.6. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with four variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
MTemp,VPS,CSC,Dil	**4**		**0.769**
MTemp,VPS,Dil,VS	4	X	0.727
MTemp,CSC,Dil,VS	4	X	0.727
MTemp,MT,Dil,VS	4	X	0.727
MTemp,Dil,Fault,VS	4	X	0.727
MTemp,VPS,Dil,Fault,VS	4	X	0.727
MTemp,VPS,Dil,Lith	4		0.708
MTemp,CSC,Dil,Lith	4		0.708
MTemp,MT,Dil,Lith	4		0.708
MTemp,Dil,Fault,Lith	4		0.708
MTemp,Dil,VS,Lith	4	X	0.708
VPS,CSC,Dil,Lith	4		0.708
VPS,MT,Dil,Lith	4		0.708
VPS,Dil,Fault,Lith	4		0.708
CSC,MT,Dil,Lith	4		0.708
CSC,Dil,Fault,Lith	4		0.708
MT,Dil,Fault,Lith	4		0.708
MTemp,CSC,MT,Dil	4	X	0.690
CSC,MT,Dil,Fault	4		0.673
VPS,Dil,VS,Lith	4	X	0.661
CSC,Dil,VS,Lith	4	X	0.661
MT,Dil,VS,Lith	4	X	0.661
Dil,Fault,VS,Lith	4	X	0.661
MTemp,CSC,Dil,Fault	4		0.654
VPS,CSC,Dil,VS	4	X	0.637
VPS,MT,Dil,VS	4	X	0.637
VPS,Dil,Fault,VS	4	X	0.637
CSC,MT,Dil,VS	4	X	0.637
CSC,Dil,Fault,VS	4	X	0.637
MT,Dil,Fault,VS	4	X	0.637
MTemp,VPS,CSC,MT	4		0.619
MTemp,VPS,CSC,Fault	4		0.619
MTemp,VPS,Dil,Fault	4		0.611
MTemp,VPS,MT,Dil	4		0.579
MTemp,VPS,CSC,VS	4	X	0.578
MTemp,CSC,MT,VS	4	X	0.578
MTemp,CSC,Fault,VS	4	X	0.578
MTemp,VPS,CSC,MT,VS	4	X	0.578
MTemp,MT,Dil,Fault	4		0.562
VPS,CSC,MT,Dil	4		0.547
VPS,MT,Dil,Fault	4		0.547
MTemp,CSC,MT,Fault	4		0.541

Table 20d.6. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with four variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
VPS,CSC,Dil,Fault	4		0.531
MTemp,CSC,VS,Lith	4	X	0.523
MTemp,VPS,MT,VS	4	X	0.517
VPS,CSC,VS,Lith	4	X	0.511
CSC,MT,VS,Lith	4	X	0.511
CSC,Fault,VS,Lith	4	X	0.511
MTemp,VPS,CSC,Lith	4		0.504
MTemp,CSC,MT,Lith	4		0.504
MTemp,CSC,Fault,Lith	4		0.504
VPS,CSC,MT,Lith	4		0.480
VPS,CSC,Fault,Lith	4		0.480
VPS,CSC,MT,VS	4	X	0.477
VPS,CSC,Fault,VS	4	X	0.477
MTemp,VPS,Fault,VS	4	X	0.469
VPS,MT,Fault,Lith	4		0.459
CSC,MT,Fault,Lith	4		0.451
VPS,CSC,MT,Fault	4		0.450
CSC,MT,Fault,VS	4	X	0.445
MTemp,MT,Fault,VS	4	X	0.435
MTemp,VPS,MT,Lith	4		0.425
MTemp,VPS,Fault,Lith	4		0.425
MTemp,MT,Fault,Lith	4		0.425
MTemp,VPS,VS,Lith	4	X	0.409
MTemp,MT,VS,Lith	4	X	0.409
MTemp,Fault,VS,Lith	4	X	0.409
VPS,MT,Fault,VS	4	X	0.409
MTemp,VPS,MT,Fault	4		0.391
VPS,MT,VS,Lith	4	X	0.383
VPS,Fault,VS,Lith	4	X	0.383
MT,Fault,VS,Lith	4	X	0.369

Table 20d.7. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with three variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
MTemp,Dil,VS	**3**	**X**	**0.727**
MTemp,Dil,Lith	3		0.708
VPS,Dil,Lith	3		0.708
CSC,Dil,Lith	3		0.708
MT,Dil,Lith	3		0.708
Dil,Fault,Lith	3		0.708
CSC,MT,Dil	3		0.673
Dil,VS,Lith	3	X	0.661
MTemp,CSC,Dil	3		0.654
VPS,Dil,VS	3	X	0.637
CSC,Dil,VS	3	X	0.637
MT,Dil,VS	3	X	0.637
Dil,Fault,VS	3	X	0.637
MT,Dil,Fault	3		0.621
MTemp,VPS,CSC	3		0.619
MTemp,VPS,Dil	3		0.611
MTemp,Dil,Fault	3		0.611
MTemp,CSC,VS	3	X	0.578
MTemp,MT,Dil	3		0.562
VPS,MT,Dil	3		0.547
MTemp,CSC,MT	3		0.541
VPS,CSC,Dil	3		0.531
VPS,Dil,Fault	3		0.531
CSC,Dil,Fault	3		0.525
CSC,VS,Lith	3	X	0.511
MTemp,CSC,Fault	3		0.504
MTemp,CSC,Lith	3		0.504
VPS,CSC,Lith	3		0.48
VPS,CSC,VS	3	X	0.477
CSC,MT,Fault	3		0.47
MTemp,VPS,VS	3	X	0.469
VPS,MT,Lith	3		0.459
CSC,MT,Lith	3		0.451
VPS,CSC,MT	3		0.45
CSC,MT,VS	3	X	0.445
MTemp,MT,Fault	3		0.439
MTemp,MT,VS	3	X	0.435
CSC,Fault,Lith	3		0.435
CSC,Fault,VS	3	X	0.434
MTemp,VPS,Lith	3		0.425
MTemp,MT,Lith	3		0.425
MTemp,Fault,Lith	3		0.425

Table 20d.7. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with three variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
VPS,Fault,Lith	3		0.422
VPS,CSC,Fault	3		0.422
MTemp,Fault,VS	3	X	0.414
MTemp,VS,Lith	3	X	0.409
VPS,MT,VS	3	X	0.409
MT,Fault,VS	3	X	0.409
MTemp,VPS,MT	3		0.391
VPS,VS,Lith	3	X	0.383
VPS,Fault,VS	3	X	0.377
MT,VS,Lith	3	X	0.369
VPS,MT,Fault	3		0.343
Fault,VS,Lith	3	X	0.34
MT,Fault,Lith	3		0.331
MTemp,VPS,Fault	3		0.311

Table 20d.8. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with two variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
Dil,Lith	**2**		**0.708**
Dil,VS	2	X	0.637
MT,Dil	2		0.621
MTemp,Dil	2		0.611
VPS,Dil	2		0.531
CSC,Dil	2		0.525
MTemp,CSC	2		0.504
CSC,MT	2		0.47
MTemp,MT	2		0.439
CSC,Lith	2		0.435
CSC,VS	2	X	0.434
MTemp,Lith	2		0.425
VPS,Lith	2		0.422
VPS,CSC	2		0.422
MTemp,VS	2	X	0.414
MT,VS	2	X	0.409
Dil,Fault	2		0.398
VPS,VS	2	X	0.377
Fault,VS	2	X	0.349
CSC,Fault	**2**		**0.345**
VPS,MT	2		0.343
VS,Lith	2	X	0.34
MT,Lith	2		0.331
VPS,Fault	2		0.32
MTemp,VPS	2		0.311
Fault,Lith	2		0.303
MT,Fault	2		0.275
MTemp,Fault	2		0.187

Table 20d.9. Results from CART Sensitivity Analysis for predicting EGS Favorable Cells with one variables used out of eight considered.

Variables Used	# Variables Used	Vertical Stress Used	r^2-value
Dil	1		0.398
VS	1	X	0.349
CSC	1		0.345
VPS	1		0.32
Lith	1		0.303
MT	1		0.275
MTemp	1		0.187
Fault	1		0.026