Summary of Rock-Eval data for the Whitehorse Trough, Yukon: Implications concerning the hydrocarbon potential of a frontier basin

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ABSTRACT

Whitehorse Trough is a frontier basin in south-central Yukon that is thought to contain gas and possibly oil. Over 400 samples from the Whitehorse Trough have been analysed by programmed pyrolysis and combustion, which together with coal rank, vitrinite reflectance, and the colour of microfossils indicate the following: the Povoas formation has no source rock potential; the Aksala formation is a poor source rock, probably gas-prone and postmature; the Richthofen formation is a poor to fair source rock, gas-prone and postmature; the Nordenskiold formation has no source rock potential; and the Tanglefoot and Tantalus formations are potentially good to very good source rocks, mainly gas-prone with a possibility of oil and mature. The Aksala and Richthofen formations are interpreted as spent source rocks, whereas the Tanglefoot and Tantalus formations are interpreted as potential source rocks and possibly effective source rocks. The most prospective areas for hydrocarbon exploration are Division Mountain, Tantalus Butte and Five Finger Rapids.

RÉSUMÉ

Le basin de Whitehorse est un bassin de région pionnière dans la partie centrale sud du Yukon qui renfermerait du gaz et peut-être du pétrole. Pour plus de 400 échantillons provenant du basin de Whitehorse, analysés par pyrolyse et combustion programmées, on a déterminé le classement du charbon, la réflectance de la vitrinite et la couleur des microfossiles; les résultats sont exposés ci-après. La Formation de Povoas ne présente aucun potentiel comme roche mère; la Formation d'Aksala constitue une mauvaise roche mère, probablement favorable à la présence de gaz et post-mature; la formation de Nordenskiold ne présente aucun potentiel comme roche mère; et les formations de Tanglefoot et de Tantalus pourraient être de bonnes à très bonnes roches mères, principalement favorables à la présence de gaz, renfermant peut-être du pétrole et parvenues à maturité. Les formations d'Aksala et de Richthofen sont interprétées comme étant des roches mères épuisées alors que les formations de Tanglefoot et de Tantalus pourraient constituer des roches mères et peut-être même des roches mères efficaces. Les régions les plus prometteuses pour l'exploration à la recherche d'hydrocarbures sont celles des monts Division et Tantalus ainsi que celle des rapides Five Finger.

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INTRODUCTION

Whitehorse Trough is one of eight oil and gas basins in the Yukon (Fig. 1). It occurs in southern Yukon and extends from just north of Carmacks, 650 km southwards, past Whitehorse and the Yukon-British Columbia border, into northern British Columbia. As a 'frontier' basin, interest in the Whitehorse Trough is based on its similarity to other Interior Cordilleran basins, such as the Bowser and Nechako basins in British Columbia, which all have a similar sedimentary history and tectonic evolution, and hence, corresponding oil and gas potential (Teitz and Young, 1982). In addition, there have been rumours of 'fire balls' and oil seeps in the Whitehorse area; Koch (1973) reported dry gas in samples from the Trough; and based on the volume and type of sedimentary rock preserved, it is estimated that the predicted potential mean oil content of the Whitehorse Trough is ~15x10^6 m^3, and the expected mean gas volume is ~136x10^6 m^3 (Osadetz, pers. comm., 2004)[2]. Given that the proposed Alaska Highway pipeline would run through the centre of the Trough, any oil and gas discoveries in the area would have a greater chance of being economically viable.

[2]*Whitehorse Trough new gas-oil potential. E-mail, Wednesday, November 3, 2004.*

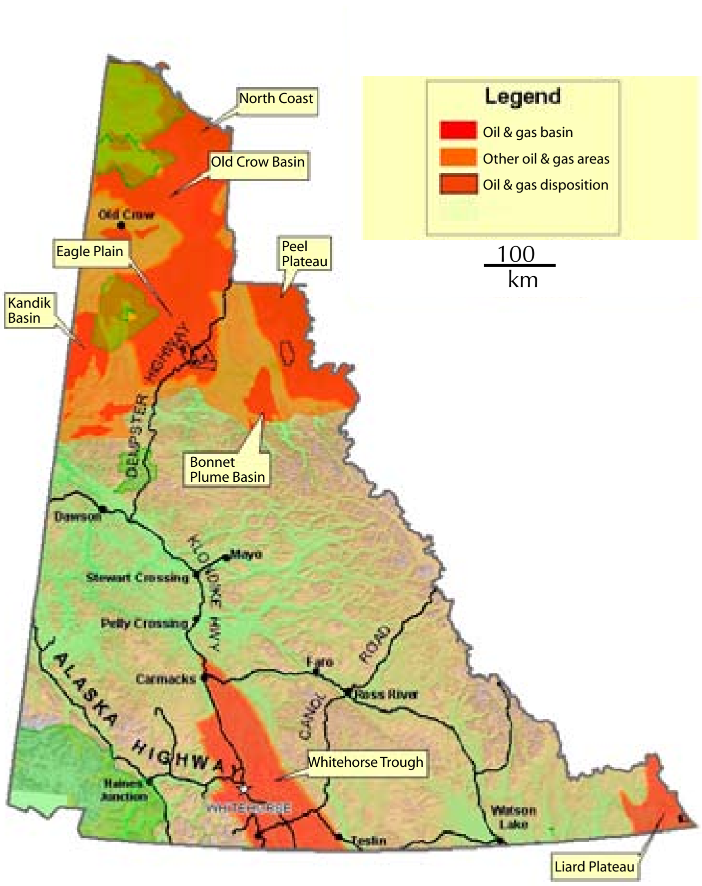

Figure 1. *Oil and gas basins in the Yukon showing the location of the Whitehorse Trough (Energy, Mines and Resources).*

The National Energy Board (2001) describes the Whitehorse Trough as an 'immature, mainly gas-prone' basin and identified potential source rocks (i.e., Triassic carbonates, Jurassic mudstones and Cretaceous mudstones), reservoirs (i.e., Triassic carbonates, and Jurassic and Cretaceous sandstones), seals (i.e., Jurassic mudstones and volcaniclastic rocks) and traps (i.e., anticlines and pinch-outs). A possible 'oil shale' in Jurassic rocks north of Whitehorse was described by Koch (1973), and Petro-Canada concluded that Jurassic rocks throughout the Whitehorse Trough have the potential to generate gas and possibly oil, whereas Cretaceous rocks have the potential to generate gas (Gilmore, 1985; Gunther, 1985). In addition, Beaton *et al.* (1992a) determined that coal seams from the Whitehorse Trough have a low potential to generate oil and gas, and Allen (2000) suggested that Jurassic rocks northwest of Whitehorse have the potential to generate gas and possibly oil. The purpose of this paper is to present the results of Rock-Eval analysis. This is a temperature-programmed geochemical whole-rock technique used to evaluate the petroleum source rock potential of the Whitehorse Trough strata in Yukon. Results of Rock-Eval analyses are supplemented with coal rank, vitrinite reflectance, conodont alteration index, and spore and pollen thermal alteration index data.

TECTONIC AND STRATIGRAPHIC SETTING

Whitehorse Trough is located in the Intermontane belt of the Canadian Cordillera. It forms part of Stikine Terrane, which is flanked to the west and east by Yukon-Tanana Terrane, and is bordered on the south by Cache Creek Terrane (Wheeler and McFeely, 1991). Whitehorse Trough is thought to have originated in Middle to Late Triassic time, and has been variably interpreted as a back-arc basin (Tempelman-Kluit, 1978; Monger and Price, 1979; Bultman, 1979), a fore-arc basin (Tempelman-Kluit, 1979, 1980; Dickie and Hein, 1995; Johannson *et al.*, 1997), a simple marginal basin (Eisbacher, 1981), or part of a complex of inter-arc basins (Monger *et al.*, 1991) and small ocean basins (Souther, 1991). Lowey and Hills (1988) demonstrated that sandstone compositions from the Whitehorse Trough indicate sedimentation in two discrete basins: sandstones from Triassic and Jurassic rocks reflect an undissected through to dissected magmatic arc provenance, compatible with a back-arc or fore-arc basin, whereas sandstones from Jura-Cretaceous rocks reflect a lithic and transitional orogenic provenance, compatible with an intra-suture embayment basin.

Wheeler (1961) introduced the term 'Whitehorse Trough' and recognized three stratigraphic units (i.e., the Lewes River and Laberge groups, and the Tantalus Formation). The Lewes River Group (Upper Triassic) was informally subdivided by Tempelman-Kluit (1984) into the lowermost Povoas formation, consisting of basalt, tuff and agglomerate, and interpreted as subaqueous lava flows, and the uppermost Aksala formation, consisting of sandstone, mudstone, conglomerate and limestone, and interpreted as deep-marine, reef, beach and tidal flat deposits (Tempelman-Kluit, 1978, 1980, 1984). The Laberge Group (Lower-Middle Jurassic) was informally subdivided by Tempelman-Kluit (1984) into four units, which from the base upwards, includes the Richthofen (i.e., thin- to medium-bedded turbidites), Conglomerate (i.e., framework-supported conglomerate), Nordenskiold (i.e., dacite tuff) and Tanglefoot (i.e., coal-bearing sandstone, mudstone and conglomerate) formations. Lowey (2004, 2005) demonstrated that the 'Conglomerate formation' is not a stratigraphic unit and these rocks can be assigned to other formations (i.e., the Richthofen and Tanglefoot formations). The Richthofen, Nordenskiold and Tanglefoot formations are interpreted as submarine fan, subaqueous pyroclastic and delta deposits, respectively (Cairnes, 1910; Lees, 1934; Bostock and Lees, 1938; Lowey, 2004). The Tantalus Formation (Upper Jurassic-Lower Cretaceous) consists of fluvial and paralic sandstone, mudstone, conglomerate and coal (Long, 1986; Lowey and Hills, 1988).

METHODS

Rock-Eval analysis is a standard screening technique used for evaluating the source rock potential of a sedimentary basin (Lafargue *et al.*, 1998). Rock-Eval 6, the latest version of the apparatus, consists of a computer-controlled, temperature-programmed pyrolysis oven and oxidation oven (Behar *et al.*, 2001; Lafargue *et al.*, 1998). An approximately 70 mg sample of pulverized whole rock is placed in the pyrolysis oven, which has a nitrogen atmosphere and is at a temperature of 300°C; after two minutes the temperature is increased to 650°C at a rate of 25°C/min (Behar *et al.*, 2001; Lafargue *et al.*, 1998; Fowler *et al.*, 2005). A flame ionization detector records the amount of hydrocarbons distilled from the sample, referred to as 'free hydrocarbons', or 'S1' in mg HC/g rock, and hydrocarbons pyrolysed from the sample, referred to as 'potential hydrocarbons', or 'S2' in mg HC/g rock; whereas an infrared cell records the amount of CO and CO_2 in the sample, referred to as 'S3' and 'S4', respectively (Behar *et al.*, 2001; Lafargue *et al.*, 1998; Fowler *et al.*, 2005). The residual sample is then cooled to 300°C, placed in the oxidation oven, and the temperature is increased to 850°C at a rate of 20°C/min (Behar *et al.*, 2001; Lafargue *et al.*, 1998). A second infrared cell records the amount of additional CO and CO_2 in the sample, which are also referred to as 'S3' and 'S4', respectively (Behar *et al.*, 2001; Lafargue *et al.*, 1998; Fowler *et al.*, 2005). The four 'acquisition parameters' (i.e., S1, S2, S3 and S4) are used to generate several 'calculated parameters', including: T_{max}, the temperature of the maximum production of pyrolysed hydrocarbons; TOC, the percent of total organic carbon (basically a sum of the acquisition parameters); OI, the oxygen index (OI=S3x100/TOC); HI, the hydrogen index (HI=S2x100/TOC); and PI, the production index (PI=S1/(S1+S2)).

Three main factors are considered in determining the potential of a rock for generating oil and gas: 1) quantity, or generative potential, based on TOC, S1 and S2; 2) quality, or type of hydrocarbon generated, based on HI and the S2/S3 ratio; and 3) maturation, or level of thermal alteration of the rock with respect to oil generation, based on PI and T_{max} (Peters, 1986; Peters and Cassa, 1994). Guidelines published by Peters (1986), Peters and Moldowan (1993), and Peters and Cassa (1994) were used for evaluating the source rock potential based on the results of the Rock-Eval analysis (see Table 1). Note that Behar *et al.* (2001), Lafargue *et al.* (1998) and Peters (1986) all advise that results of programmed pyrolysis from outcrop samples be interpreted with caution (i.e., organic matter may have been oxidized, resulting in low S1 and S2 values and high T_{max} values) and supported by other analyses (i.e., vitrinite reflectance). T_{max} is also affected by the type of organic matter and minerals in the matrix of the sample (Peters, 1986). In addition, Peters (1986) cautions that samples with S2 values <0.2 mg HC/g rock are commonly inaccurate and should be rejected, whereas Natural Resources Canada (2004)[3] suggests that if TOC ≤0.3%, all parameters have questionable significance; if TOC ≤ 0.5%, OI has questionable significance; and if S1 and S2 ≤0.2 mg HC/g rock, T_{max}

[3]*www.em.gov.bc.ca/dl/oilgas/cog/geofile200301/doc/html/rockeval.htm*

and PI have questionable significance. In addition, Waples (1985) notes that results of Rock-Eval analysis provides information only on the present-day hydrocarbon generative capacity of kerogen in the rock, that is, mature to overmature rocks may have generated hydrocarbons previously.

Previous Rock-Eval analyses for the Yukon portion of the Whitehorse Trough (i.e., 124 samples) were presented by Gilmore (1985), Gunther (1985), Beaton *et al.* (1992a) and Allen (2000). This paper presents the results of 443 samples that were collected from outcrop and drill core of limestone, sandstone-mudstone couplets and mudstone throughout the Whitehorse Trough in Yukon (and includes Rock-Eval results for the Richthofen formation that were previously reported by Lowey, 2005). The analyses were performed on a Rock-Eval 6 'Turbo' apparatus by the Geological Survey of Canada at Calgary, Alberta (Appendix 1).

Table 1. *Programmed pyrolysis and oxidation guidelines describing source rock quantity, quality and maturation parameters (Peters and Cassa, 1994).*

Quantity	TOC (wt.%)	S_1 (mg HC/ g rock)	S_2 (mg HC/ g rock)
Poor	0-0.5	0-0.5	0-2.5
Fair	0.5-1	0.5-1	2.5-5
Good	1-2	1-2	5-10
Very good	2-4	2-4	10-20
Excellent	>4	>4	>20
Quality	HI (mg HC/ g TOC)	S_2/S_3	Kerogen type
None	<50	<1	IV
Gas	50-200	1-5	III
Gas and oil	200-300	5-10	II/III
Oil	300-600	10-15	II
Oil	>600	>15	I
Maturation	R_o (%)	T_{max} (°C)	TAI
Immature	0.2-0.6	<435	1.5-2.6
Early	0.6-0.65	435-445	2.6-2.6
Mature Peak	0.65-0.9	445-450	2.7-2.9
Late	0.9-1.35	450-470	2.9-3.3
Postmature	>1.35	>470	>3.3

RESULTS

Lewes River Group

The Povoas formation consists of volcanic rocks and no samples were analysed by Rock-Eval. The Aksala formation does not contain abundant transported organic material (Long, 2005), but mudstone is present, and the National Energy Board (2001) suggested that a 'fetid limestone' was a possible source rock. Hence, only a few samples were analysed by Rock-Eval, and these results show that both the fetid limestone (i.e., samples GL03-6A, GL04-39A and GL04-97A) and mudstone (i.e., samples GL04-67B and GL04-68A) contain very small amounts of TOC, S1 and S2 (Fig. 2), indicating that, in terms of quantity, it is a poor source rock. Due to the low values of these parameters, determining the petroleum quality of the rock is not very accurate; hence, HI should be ignored, although the S2/S3 ratio is valid and indicates that only gas would be expected (Fig. 3). The thermal maturation of the samples cannot be determined because of the low values for TOC, S1 and S2.

Laberge Group

Koch (1973) and the National Energy Board (2001) suggested that thin-bedded sandstone-mudstone couplets in the Richthofen formation resemble an 'oil shale' and are a potential source rock. However, Rock-Eval analysis of 70 samples shows that this unit contains only small amounts of TOC, S1 and S2 (Fig. 4), indicating that in terms of quantity, it is a poor and possibly a fair source rock. In terms of quality, only gas would be expected (Fig. 5). Due to the low values for S1 and S2, determining the thermal maturation of the samples is not very accurate, hence PI should be ignored, but two values for T_{max} are valid and these indicate the unit is postmature (Fig. 6).

The Nordenskiold formation consists mostly of dacite tuff; it is not considered a source rock and no samples were analysed by Rock-Eval.

The Tanglefoot formation was not considered by the National Energy Board (2001) as a potential source rock. However, Rock-Eval analysis of 182 samples shows that this unit contains large amounts of TOC, small amounts of S1 and moderate amounts of S2 (Fig. 7), indicating that in terms of quantity, it is a good to very good source rock. In terms of quality, mainly gas would be present, but there is also the possibility of oil (Fig. 8). Also, the thermal maturation of the samples appear to be late immature according to PI, and early mature according to T_{max} (Fig. 9).

Prospective areas for gas and oil generation are Division Mountain (located approximately half-way between Whitehorse and Carmacks), Tantalus Butte (located at Carmacks) and Five Finger Rapids (located north of Carmacks). At all of the localities, hydrocarbon fluid inclusions were observed in the macerals (V. Stasiuk, per. comm., 2005)[4].

[4]*Vitrinite reflectance data, Whitehorse Trough. E-mail, Wednesday, November 6, 2005.*

Tantalus Formation

The National Energy Board (2001) described the Tantalus Formation as a potential source rock. Rock-Eval analysis of 186 samples shows that this unit contains moderate amounts of TOC, small amounts of S1 and moderate amounts of S2 (Fig. 10), indicating that in terms of quantity, it is a good to very good source rock. In terms of quality, mainly gas would be present, but there is also the possibility of oil (Fig. 11). Also, the thermal maturation of the samples appears to be late immature according to PI, and early mature according to T_{max} (Fig. 12). Hydrocarbon fluid inclusions were observed in the macerals at Tantalus Butte (V. Stasiuk, personal communication, 2005), which is the only prospective area for gas and oil generation in the Tantalus Formation.

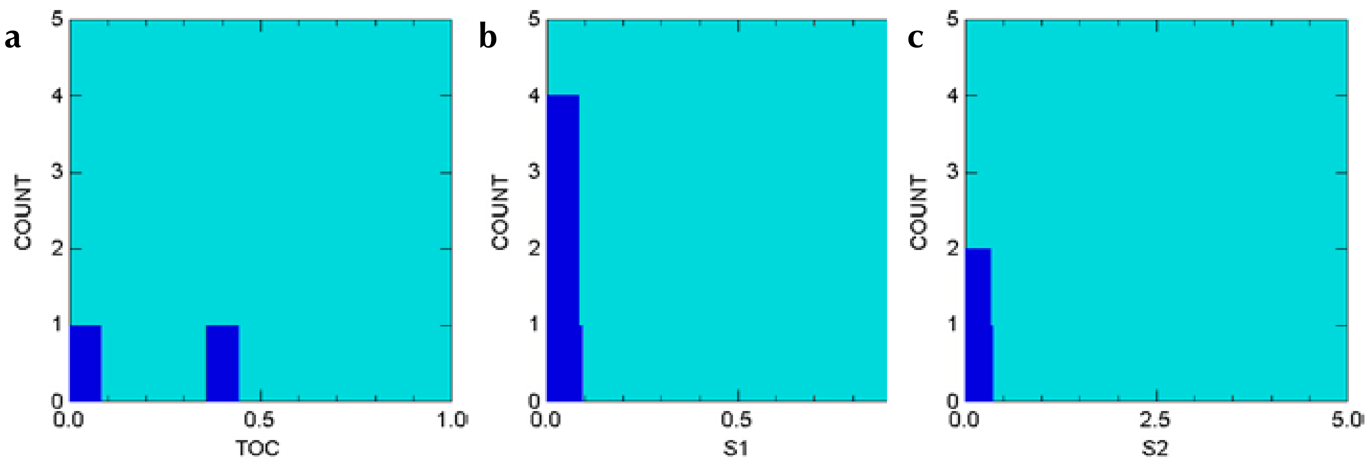

Figure 2. *Rock-Eval quantity parameters, Aksala formation.*

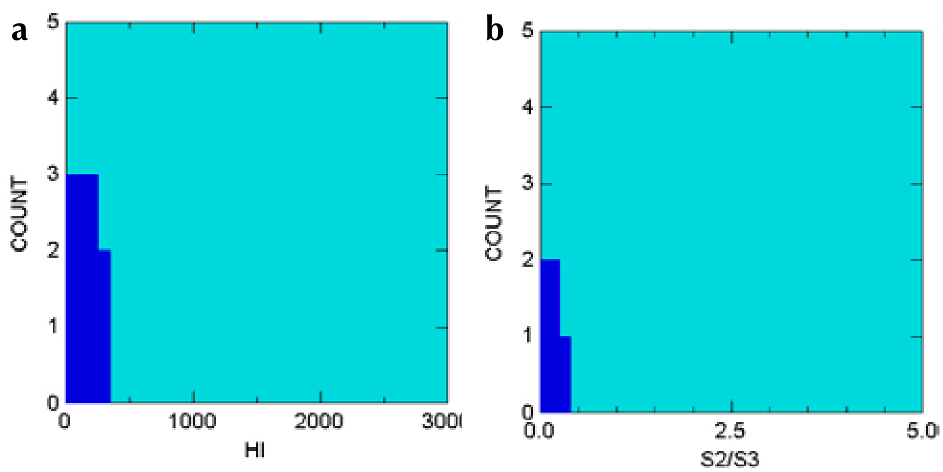

Figure 3. *Rock-Eval quality parameters, Aksala formation.*

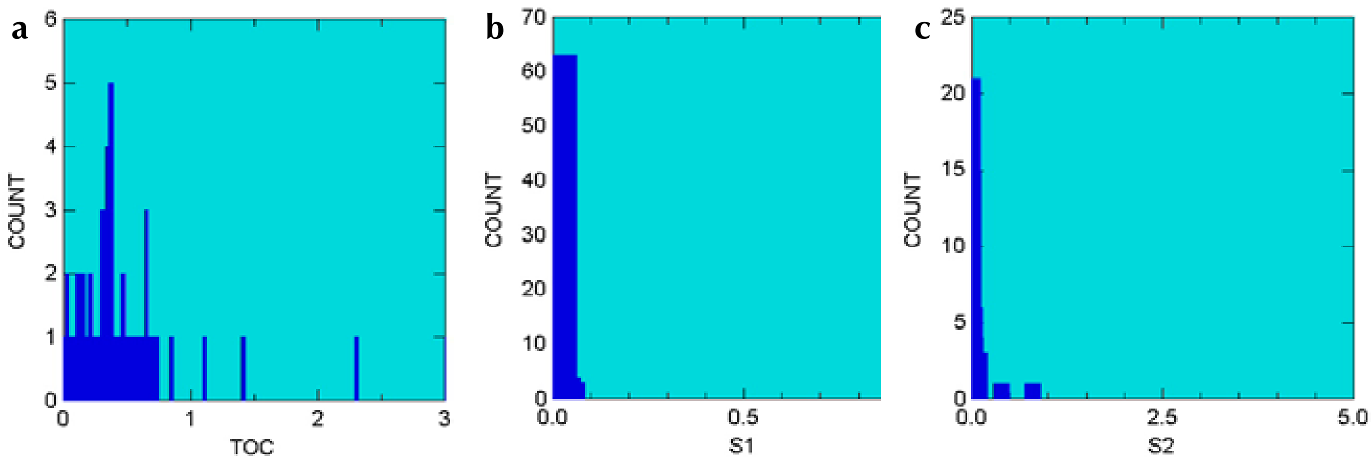

Figure 4. *Rock-Eval quantity parameters, Richthofen formation.*

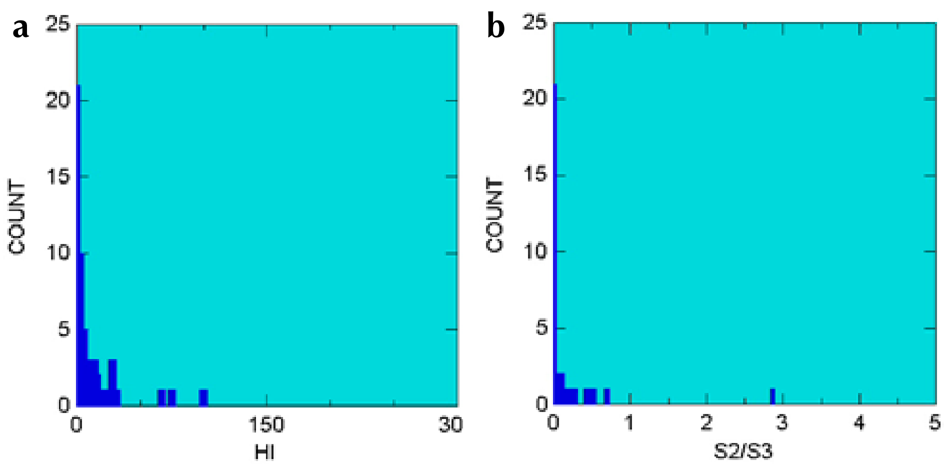

Figure 5. *Rock-Eval quality parameters, Richthofen formation.*

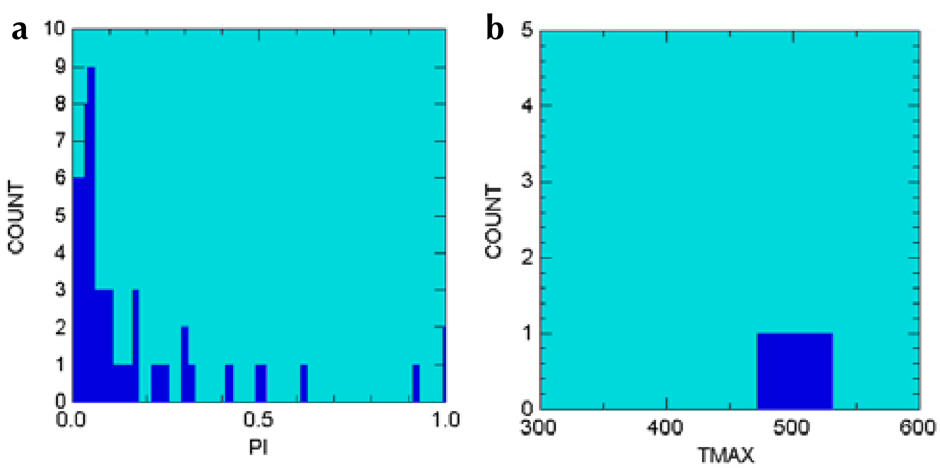

Figure 6. *Rock-Eval maturation parameters, Richthofen formation.*

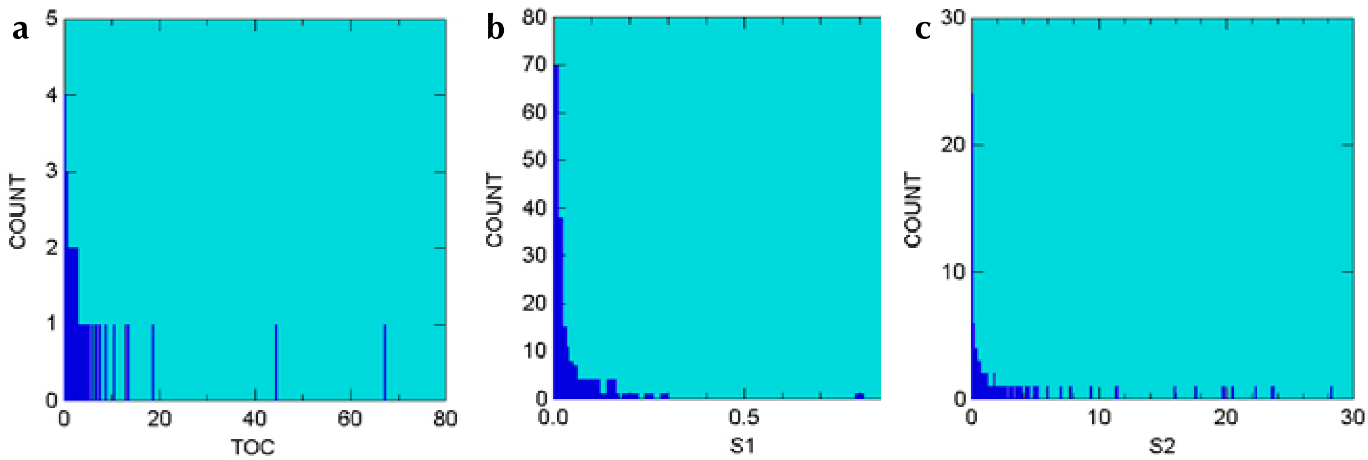

Figure 7. *Rock-Eval quantity parameters, Tanglefoot formation.*

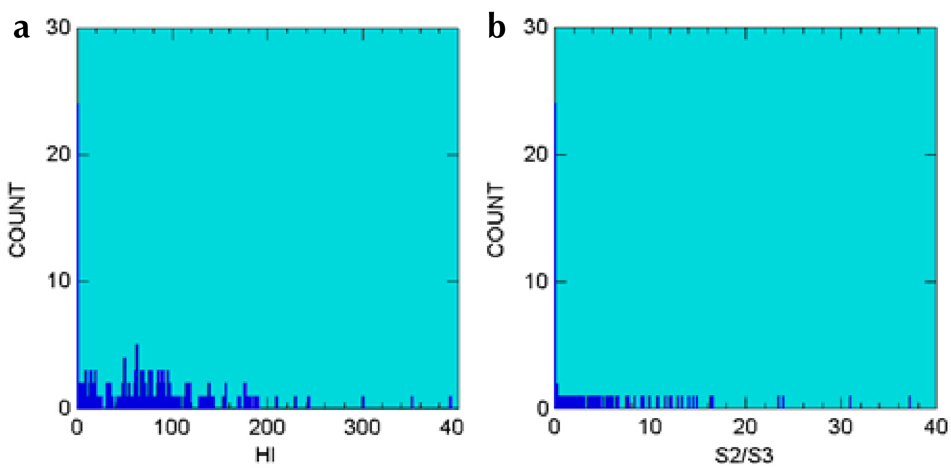

Figure 8. *Rock-Eval quality parameters, Tanglefoot formation.*

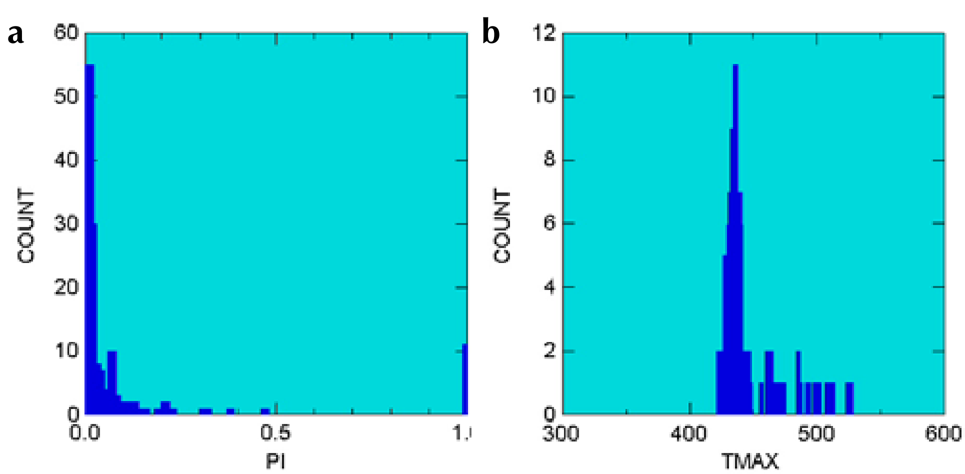

Figure 9. *Rock-Eval maturation parameters, Tanglefoot formation.*

DISCUSSION AND CONCLUSIONS

The Povoas formation is not considered a source rock based on its lithology. The Aksala formation is a poor source rock and gas-prone. The thermal maturation of the unit could not be determined by Rock-Eval analysis. However, over 40 samples have been analysed for conodonts, and these indicate a conodont alteration index (CAI) of 5 in the Whitehorse area, and 2 to 4 in the Carmacks area (England, 1980; Hart, 1997; Tempelman-Kluit, 1980). Note that the 'oil window' occurs between a CAI of 1.5 and 2 (Fowler *et al.*, 2005). Also, Tempelman-Kluit (1978) reported that pyrobitumen (i.e., thermally altered solidified bitumen) occurs locally in fractures and cavities in limestone. Hence, the Aksala formation is probably postmature and is interpreted as a 'spent' source rock, implying that it has reached the postmature stage and is incapable of further oil generation, but it still may be able to generate wet and dry gas (Peters and Cassa, 1994).

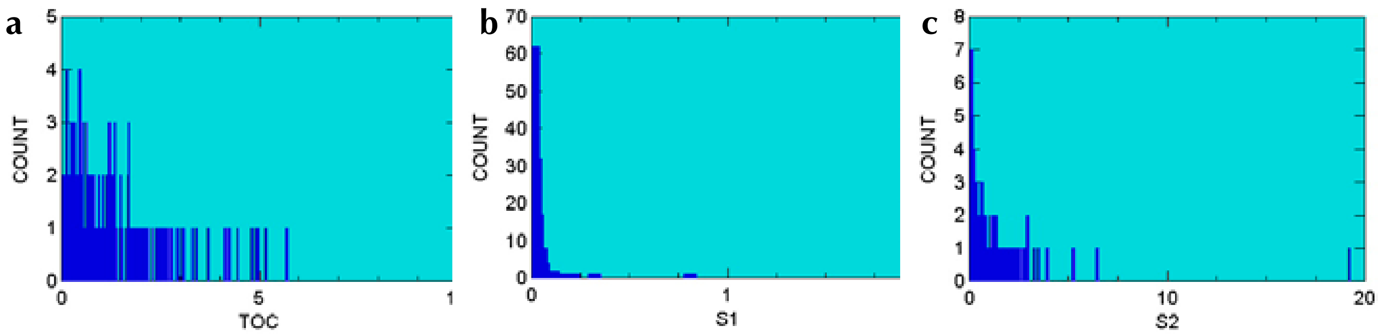

Figure 10. *Rock-Eval quantity parameters, Tantalus Formation.*

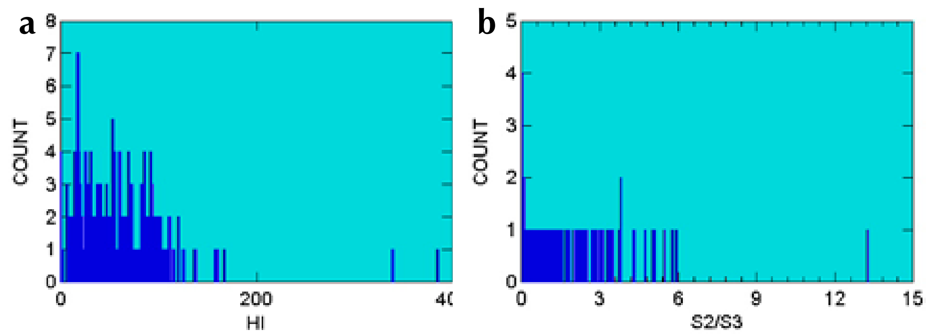

Figure 11. *Rock-Eval quality parameters, Tantalus Formation.*

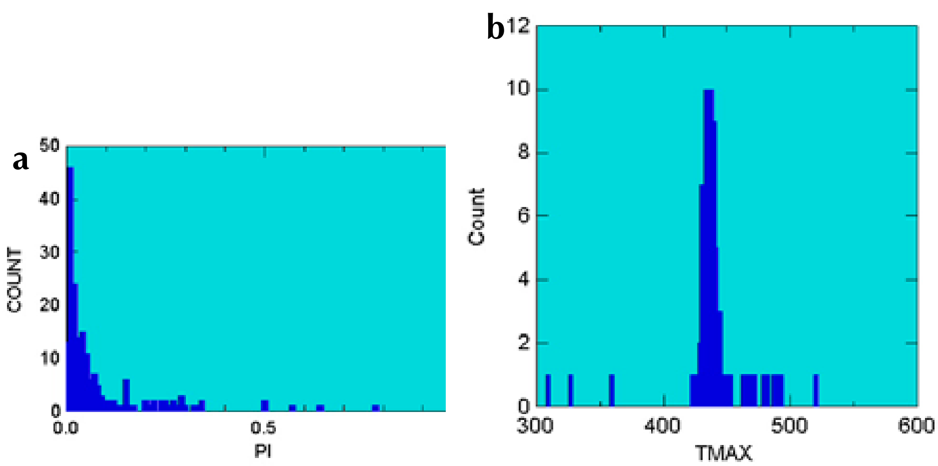

Figure 12. *Rock-Eval maturation parameters, Tantalus Formation.*

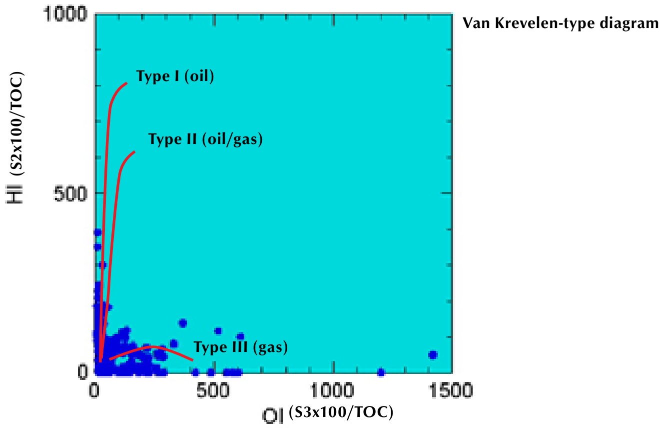

Figure 13. *OI-HI diagram, Tanglefoot Formation.*

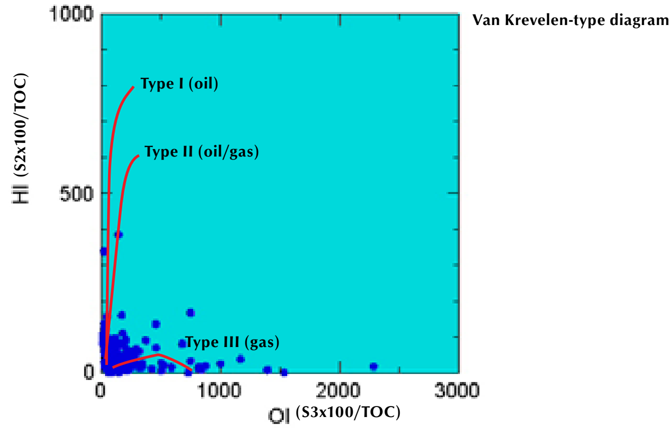

Figure 14. *OI-HI diagram, Tantalus Formation.*

The Richthofen formation is a poor to fair source rock, gas-prone and postmature. English *et al.* (2005) reached a similar conclusion for the correlative Inklin Formation in the Whitehorse Trough in northern British Columbia. The Nordenskiold formation is not considered a source rock based on its lithology. The Tanglefoot formation is a good to very good source rock, and mainly gas-prone with a possibility of oil. The possibility of oil generation is supported by the OI-HI Van Krevelen-type diagram (Fig. 13). Although most samples plot along the Type III axis (i.e., gas-prone kerogen from terrestrial plants), several samples have HI values greater than 200 and plot along the Type I and Type II kerogen axes (i.e., lacustine and marine kerogen, respectively). HI values greater than 200 and Type I and Type II macerels are conducive to oil generation (Peters and Cassa, 1994; Tissot and Welte, 1984). Oil generation is marginally supported by the composition of coal in the Tanglefoot formation. Beaton *et al.* (1992b) determined that the coal contains 13% liptinite (basically amorphous or structureless organic matter). According to Peters and Cassa (1994), 15-20% liptinite is required for coal to generate oil. The Rock-Eval PI indicates that the Tanglefoot formation is late immature, whereas T_{max} indicates it is early mature. Coal rank in the Tanglefoot formation is high-volatile C to B bituminous (Cameron and Beaton, 2000; Beaton *et al.*, 1992b), corresponding to the beginning half of the oil window (Fowler *et al.*, 2005). According to Stack *et al.* (1982), economic accumulations of petroleum occur where the coal is less than or equal to high-volatile bituminous rank. Also, random vitrinite reflectance values for the Tanglefoot formation range from 0.48-0.61% (Cameron and Beaton, 2000; Beaton *et al.*, 1992a,b; Russell, 1978; V. Stasiuk, personal communication, 2005), averaging ~0.58% (Beaton *et al.*, 1992b), corresponding also to the beginning half of the oil window. In addition, spore and pollen from this unit are brown-black to brown in colour (Sweet, 2004), indicating a thermal alteration index (TAI) of 3 to 4; the oil window occurs between a TAI of ~2-3.5 (Fowler *et al.*, 2005). Hence, the Tanglefoot formation is probably early mature and is interpreted as a 'potential' source rock (i.e., the rock contains adequate quantities of organic matter to generate petroleum; Peters and Cassa, 1994), and possibly an 'effective' source rock (i.e., the rock is, or has, generated and expelled petroleum; Peters and Cassa, 1994). Three potentially petroliferous source-rock pods in the Tanglefoot formation are identified in the northern portion of the Whitehorse Trough at Division Mountain, Tantalus Butte and Five Finger Rapids.

The Tantalus Formation is a good to very good source rock and mainly gas-prone with a possibility of oil.

The possibility of oil generation is supported by the OI-HI Van Krevelen-type diagram (Fig. 14). Although most samples plot along the Type III axis (i.e., gas-prone terrestrial kerogen), several samples have HI values greater than 200 and plot along the Type I and Type II kerogen axes (i.e., oil-prone lacustrine and marine kerogen). However, oil generation is not supported by the composition of coal in the Tantalus Formation: Beaton *et al.* (1992b) determined that the coal contains only 2-7% liptinite. The Rock-Eval PI indicates that the Tantalus Formation is late immature, whereas T_{max} indicates it is early mature. Coal rank in the Tantalus Formation is high-volatile B to A bituminous (Cameron and Beaton, 2000; Beaton *et al.*, 1992a,b; Swartzman, 1948), corresponding to the middle of the oil window (Fowler *et al.*, 2005). Also, random vitrinite reflectance values for the Tantalus Formation range from 0.61-1.09% (Cameron and Beaton, 2000; Hacquebard, 1972; Russell, 1978; V. Stasiuk, personal communication, 2005), corresponding to the middle of the oil window, although Hunt and Hart (1994) reported values of 1.68-3.45%, but the latter are due to intrusion of rhyolite sills. In addition, spore and pollen from this unit are brown-black to brown (Sweet, 2004), indicating a thermal alteration index (TAI) of 3 to 4. Hence, the Tanglefoot formation is probably early to peak mature, and is interpreted as a potential source rock, and possibly an effective source rock. One potentially petroliferous source rock pod in the Tantalus Formation is identified in the northern portion of the Whitehorse Trough at Tantalus Butte.

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APPENDIX 1: RESULTS OF ROCK-EVAL 6 ANALYSIS

For explanation of abbreviations of headings, see description in text in section on Methods.

Aksala Formation

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
GL03-6A	426085	6915152	-40	0.00	0.00	0.68	1.00	0.00	0.40	0	170
GL04-39A	491169	6775460	439	0.01	0.04	0.27	0.19	0.15	0.04	100	675
GL04-67B	485092	6717134	402	0.00	0.01	0.30	0.02	0.03	0.01	100	3000
GL04-68A	485164	6716803	400	0.00	0.01	0.26	0.00	0.04	0.00	0	0
GL04-97A	507428	6765766	459	0.00	0.00	0.20	0.19	0.00	0.02	0	1000

Richthofen Formation

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
GL03-90A	489245	6772712	-40	0.00	0.00	0.16	1.00	0.00	0.85	0	19
GL03-90B	489245	6772712	-40	0.00	0.00	0.29	0.00	0.00	0.37	0	78
GL03-81R	489919	6770781	411	0.00	0.02	0.45	0.04	0.04	0.43	5	105
GL04-01A	482978	6802442	494	0.00	0.09	0.99	0.01	0.09	0.32	28	309
GL04-02A	482393	6803720	497	0.02	0.38	0.55	0.04	0.69	1.41	28	39
GL04-03A	482168	6804552	491	0.01	0.10	0.24	0.06	0.42	0.37	27	65
GL04-05A	482623	6799519	508	0.00	0.03	0.93	0.05	0.03	0.21	14	443
GL04-08A	480760	6799644	496	0.00	0.10	0.19	0.03	0.53	0.48	21	40
GL04-08B	480760	6799644	506	0.02	0.80	0.28	0.02	2.86	3.02	28	9
GL04-10A	482916	6796053	506	0.00	0.09	0.19	0.03	0.47	0.58	16	33
GL04-16A	485588	6792821	511	0.00	0.04	0.16	0.02	0.25	0.39	10	41
GL04-16B	485588	6792821	490	0.00	0.00	0.18	0.09	0.00	0.09	0	200
GL04-16C	485588	6792821	519	0.00	0.10	0.20	0.01	0.50	1.11	9	18
GL04-17A	487670	6784498	414	0.00	0.04	0.53	0.01	0.08	0.52	8	102
GL04-18A	487314	6784785	406	0.00	0.04	0.41	0.04	0.10	0.74	5	55
GL04-19A	487296	6785151	395	0.00	0.02	0.30	0.08	0.07	0.33	6	91
GL04-20A	487103	6785663	419	0.00	0.01	0.20	0.11	0.05	0.14	7	143
GL04-22A	486673	6786747	417	0.00	0.00	0.32	0.10	0.00	0.16	0	200
GL04-23A	486360	6788169	404	0.00	0.00	0.23	0.09	0.00	0.17	0	135
GL04-24A	489553	6778917	427	0.00	0.00	0.39	0.15	0.00	0.32	0	122
GL04-26A	489406	6778202	415	0.00	0.01	0.25	0.08	0.04	0.35	3	71
GL04-27A	489383	6779415	372	0.01	0.01	0.30	0.51	0.03	0.30	3	100
GL04-28A	489268	6780112	390	0.00	0.00	0.10	0.00	0.00	0.11	0	91
GL04-29A	489175	6780655	363	0.00	0.00	0.18	0.01	0.00	0.03	0	600
GL04-30A	489037	6781689	427	0.00	0.04	0.25	0.05	0.16	0.13	31	192
GL04-31A	488848	6782553	425	0.00	0.01	0.14	0.07	0.07	0.36	3	39
GL04-32A	488094	6783424	400	0.00	0.01	0.28	0.01	0.04	0.15	7	187
GL04-33A	491444	6771562	443	0.00	0.01	0.36	0.02	0.03	0.11	9	327

Richthofen formation (continued)

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
GL04-34A	491725	6771506	412	0.00	0.01	0.24	0.04	0.04	0.01	100	2400
GL04-36A	492078	6772503	394	0.00	0.00	0.27	0.32	0.00	0.51	0	53
GL04-38A	491169	6775360	380	0.00	0.01	0.28	0.03	0.04	0.31	3	90
GL04-41A	489115	6773985	410	0.00	0.00	0.25	0.14	0.00	0.61	0	41
GL04-42A	489883	6775821	418	0.00	0.02	0.66	0.10	0.03	0.03	67	2200
GL04-43A	490070	6775227	379	0.00	0.03	0.27	0.02	0.11	0.04	75	675
GL04-44A	490421	6773773	406	0.00	0.01	0.19	0.10	0.05	0.05	20	380
GL04-45A	490594	6768588	425	0.00	0.05	0.39	0.05	0.13	0.36	14	108
GL04-47A	488682	6795733	591	0.00	0.01	0.23	0.02	0.04	0.67	1	34
GL04-48A	488298	6794223	568	0.00	0.01	0.85	0.25	0.01	0.32	3	266
GL04-48B	488298	6794223	538	0.00	0.02	0.43	0.17	0.05	0.65	3	66
GL04-48C	488298	6794223	418	0.00	0.00	0.31	0.42	0.00	0.37	0	84
GL04-49A	489163	6793656	439	0.00	0.08	0.55	0.05	0.15	0.31	26	177
GL04-50A	488339	6791663	544	0.00	0.00	0.16	0.05	0.00	0.13	0	123
GL04-52A	489026	6789126	569	0.00	0.02	0.19	0.04	0.11	0.37	5	51
GL04-53A	489319	6788320	552	0.00	0.02	0.19	0.01	0.11	0.65	3	29
GL04-55A	494422	6776779	493	0.02	0.05	0.11	0.24	0.45	0.21	24	52
GL04-56A	495108	6775504	496	0.01	0.03	0.13	0.13	0.23	0.19	16	68
GL04-57A	495525	6774105	511	0.01	0.05	0.18	0.17	0.28	0.35	14	51
GL04-59A	493297	6763660	417	0.00	0.09	0.50	0.05	0.18	0.49	18	102
GL04-59B	493297	6763660	410	0.00	0.02	0.18	0.05	0.11	0.31	6	58
GL04-60A	491993	6766061	394	0.00	0.00	0.12	0.22	0.00	0.18	0	67
GL04-60B	491993	6766061	425	0.00	0.03	0.57	0.00	0.05	0.25	12	228
GL04-61A	491415	6766150	402	0.00	0.02	0.36	0.04	0.06	0.26	8	138
GL04-63A	492320	6765079	419	0.00	0.08	1.29	0.03	0.06	2.30	3	56
GL04-65A	474962	6788368	452	0.00	0.01	0.59	0.07	0.02	0.40	3	148
GL04-69A	542111	6689770	422	0.00	0.03	0.56	0.04	0.05	0.65	5	86
GL04-72A	538399	6697887	328	0.00	0.00	0.71	0.30	0.00	0.45	0	158
GL04-74A	490495	6760518	598	0.00	0.00	0.24	0.92	0.00	0.55	0	44
GL04-76A	545510	6682568	387	0.00	0.01	0.25	0.09	0.04	0.37	3	68
GL04-78B	517479	6671919	374	0.00	0.00	0.16	0.50	0.00	0.70	0	23
GL04-79A	501900	6651051	392	0.00	0.00	0.17	0.12	0.00	0.62	0	27
GL04-83A	491538	6763490	431	0.00	0.02	0.40	0.02	0.05	0.35	6	114
GL04-85B	491119	6763203	438	0.00	0.01	0.34	0.03	0.03	0.28	4	121
GL04-86A	491441	6763165	431	0.00	0.01	0.48	0.05	0.02	0.68	1	71
GL04-92A	489819	6759345	416	0.00	0.02	0.44	0.07	0.05	0.42	5	105
GL04-92C	489819	6759345	410	0.00	0.03	0.54	0.05	0.06	0.35	9	154
GL04-93A	490232	6759119	319	0.00	0.00	0.50	0.30	0.00	0.47	0	106
GL04-93C	490232	6759119	316	0.00	0.00	0.25	0.62	0.00	0.63	0	40
GL04-94B	492711	6760581	-40	0.00	0.00	0.35	1.00	0.00	0.47	0	74
GL04-95A	492000	6761523	433	0.00	0.05	0.46	0.04	0.11	0.29	17	159
GL04-101B	506577	6765794	443	0.00	0.00	0.33	0.17	0.00	0.16	0	206

Tanglefoot Formation

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
C-76-01-015	434000	6889070	440	0.00	0.52	3.23	0.00	0.16	1.53	35	211
C-76-01-032	434000	6889070	456	0.00	0.04	0.66	0.05	0.06	0.32	13	206
C-76-01-042	434000	6889070	435	0.09	15.90	4.73	0.01	3.36	8.78	182	54
C-76-01-043	434000	6889070	431	0.04	0.57	1.20	0.07	0.48	1.04	56	115
C-76-01-046	434000	6889070	437	0.00	0.10	1.06	0.02	0.09	0.47	21	226
C-76-03-320	433900	6889920	501	0.09	30.03	13.91	0.00	2.16	67.18	46	21
C-76-03-364	433900	6889920	440	0.00	0.04	0.40	0.02	0.10	0.22	18	182
C-76-03-384	433900	6889920	429	0.01	1.44	0.39	0.01	3.69	1.52	95	26
C-76-03-444	433900	6889920	436	0.08	23.61	1.01	0.00	23.38	10.40	229	10
C-76-03-483	433900	6889920	428	0.02	2.49	0.50	0.01	4.98	1.89	132	26
C-76-03-540	433900	6889920	438	0.02	3.79	0.90	0.01	4.21	3.57	108	25
C-76-03-555	433900	6889920	438	0.04	11.42	0.99	0.00	11.54	7.41	156	13
C-76-03-595	433900	6889920	429	0.03	2.45	0.62	0.01	3.95	2.15	114	29
C-76-03-625	433900	6889920	439	0.05	3.19	0.53	0.02	6.02	2.31	139	23
C-76-03-637	433900	6889920	435	0.01	1.15	0.28	0.01	4.11	1.24	94	23
C-76-03-638	433900	6889920	436	0.01	0.99	0.39	0.01	2.54	1.26	79	31
C-76-03-639	433900	6889920	432	0.01	1.17	0.52	0.01	2.25	1.35	87	39
C-76-03-656	433900	6889920	436	0.00	0.50	0.46	0.00	1.09	0.80	63	58
C-76-03-730	433900	6889920	437	0.01	0.82	0.99	0.01	0.83	1.07	78	93
C-76-03-761	433900	6889920	436	0.01	0.58	0.30	0.01	1.93	0.71	82	42
C-76-03-762	433900	6889920	434	0.00	0.58	0.32	0.01	1.81	0.76	76	42
C-76-03-786	433900	6889920	437	0.07	19.77	1.33	0.00	14.86	12.80	156	10
C-76-03-796	433900	6889920	431	0.01	0.62	1.83	0.02	0.34	1.03	60	178
C-76-03-799	433900	6889920	443	0.03	4.34	0.47	0.01	9.23	2.48	176	19
C-76-04-312	434600	6884035	524	0.02	0.81	0.55	0.02	1.47	2.55	33	22
C-76-04-483	434600	6884035	436	0.00	0.00	0.52	0.02	0.00	0.09	0	578
C-76-04-503	434600	6884035	498	0.08	0.32	0.52	0.19	0.62	0.72	44	72
C-76-05-413	433900	6889920	446	0.03	4.87	1.70	0.01	2.86	5.70	87	30
C-76-05-460	433900	6889920	436	0.05	4.99	0.65	0.01	7.68	2.86	176	23
C-76-05-465	433900	6889920	433	0.04	3.87	0.83	0.01	4.66	2.76	141	30
C-76-05-468	433900	6889920	434	0.09	4.35	1.14	0.02	3.82	3.18	138	36
C-76-05-498	433900	6889920	434	0.01	1.68	1.09	0.01	1.54	2.00	85	55
C-76-05-499	433900	6889920	433	0.01	1.74	1.30	0.00	1.34	2.07	85	63
C-76-05-537	433900	6889920	439	0.02	4.42	0.98	0.00	4.51	4.96	90	20
C-76-05-538	433900	6889920	432	0.02	1.07	0.62	0.01	1.73	1.20	89	52
C-76-06-252	434760	6883730	461	0.00	0.03	0.36	0.02	0.08	0.21	14	171
C-76-06-345	434760	6883730	462	0.05	3.41	0.28	0.01	12.18	2.65	131	11
C-76-06-362	434760	6883730	471	0.01	0.47	0.25	0.02	1.88	0.96	50	26
C-76-06-408	434760	6883730	485	0.01	0.90	0.33	0.01	2.73	2.72	35	12
C-76-06-412	434760	6883730	515	0.00	0.19	0.17	0.00	1.12	0.98	19	17
C-76-06-516	434760	6883730	493	0.01	0.23	0.39	0.03	0.59	0.37	65	105
C-76-07-573	434655	6884080	476	0.00	0.01	0.18	0.00	0.06	0.07	14	257

Tanglefoot formation (continued)

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
C-76-07-598	434655	6884080	511	0.00	0.00	0.16	0.14	0.00	0.06	0	267
C-76-07-750	434655	6884080	440	0.00	1.02	0.38	0.00	2.68	1.15	90	33
C-76-08-030	434080	6890040	433	0.01	0.94	0.73	0.01	1.29	1.04	91	70
C-76-08-040	434080	6890040	440	0.00	0.08	0.88	0.02	0.09	0.43	19	205
C-76-08-049	434080	6890040	435	0.01	1.14	0.73	0.01	1.56	1.26	91	58
C-76-08-054	434080	6890040	433	0.00	0.17	0.96	0.02	0.18	0.67	25	143
C-76-08-060	434080	6890040	442	0.01	1.02	0.37	0.01	2.76	1.35	77	27
C-76-08-075	434080	6890040	438	0.06	11.32	0.76	0.01	14.89	6.46	177	12
C-76-08-142	434080	6890040	437	0.00	0.32	0.32	0.01	1.00	0.28	114	114
C-76-08-164	434080	6890040	438	0.00	0.64	0.71	0.00	0.90	0.67	97	106
C-76-08-168	434080	6890040	433	0.03	3.92	0.42	0.01	9.33	1.31	300	32
C-76-08-183	434080	6890040	441	0.00	0.31	0.44	0.01	0.70	0.45	69	98
C-76-08-184	434080	6890040	437	0.01	1.54	0.28	0.01	5.50	1.16	134	24
C-76-08-206	434080	6890040	433	0.00	0.66	0.54	0.01	1.22	0.86	78	63
C-76-08-215	434080	6890040	439	0.01	0.41	0.31	0.02	1.32	0.65	63	48
C-76-08-219	434080	6890040	436	0.01	1.23	0.40	0.01	3.08	1.58	78	25
C-76-08-220	434080	6890040	436	0.01	0.67	0.47	0.02	1.43	1.02	67	46
C-76-08-254	434080	6890040	432	0.00	0.34	0.32	0.01	1.06	0.60	57	53
C-76-08-270	434080	6890040	434	0.00	0.21	0.35	0.01	0.60	0.28	75	125
C-76-08-386	434080	6890040	440	0.00	0.61	0.37	0.00	1.65	1.00	62	37
C-76-08-390	434080	6890040	432	0.00	0.35	0.41	0.00	0.85	0.51	69	80
C-76-08-394	434080	6890040	438	0.01	0.82	0.46	0.01	1.78	1.20	69	38
C-76-08-411	434080	6890040	431	0.00	0.19	0.23	0.00	0.83	0.40	48	58
C-76-08-415	434080	6890040	439	0.00	0.34	0.67	0.01	0.51	0.54	63	124
C-76-08-435	434080	6890040	428	0.00	0.08	0.34	0.00	0.24	0.12	67	283
C-76-08-450	434080	6890040	432	0.00	0.07	0.31	0.01	0.23	0.06	117	517
C-76-09-094	434050	6890100	432	0.00	0.12	0.39	0.00	0.31	0.18	67	217
C-76-09-113	434050	6890100	438	0.00	0.30	0.40	0.02	0.75	0.31	97	129
C-76-09-114	434050	6890100	436	0.01	0.77	0.31	0.01	2.48	1.07	73	29
C-76-09-121	434050	6890100	431	0.00	0.50	0.49	0.01	1.02	0.58	86	84
C-76-09-132	434050	6890100	431	0.01	1.30	0.52	0.01	2.50	1.34	98	39
C-76-09-148	434050	6890100	433	0.01	0.14	0.47	0.04	0.30	0.26	54	181
C-76-09-149	434050	6890100	441	0.00	0.29	0.88	0.00	0.33	0.41	71	215
C-76-09-159	434050	6890100	431	0.01	0.27	0.57	0.02	0.47	0.36	75	158
C-76-10-645	434785	6883720	485	0.15	20.49	1.46	0.01	14.03	18.62	112	8
C-76-10-654	434785	6883720	465	0.01	0.54	0.43	0.02	1.26	1.10	50	39
C-76-12-170	434980	6883475	489	0.01	0.13	0.25	0.06	0.52	0.19	68	132
C-76-12-261	434980	6883475	470	0.04	0.92	0.61	0.04	1.51	1.27	74	48
C-76-12-264	434980	6883475	468	0.04	1.16	0.25	0.04	4.64	1.99	60	13
C-76-12-376	434980	6883475	498	0.01	0.08	0.43	0.15	0.19	0.19	42	226
C-76-12-402	434980	6883475	452	0.01	0.08	0.33	0.07	0.24	0.10	80	330
C-76-12-412	434980	6883475	498	0.01	0.09	0.55	0.08	0.16	0.09	100	611

Tanglefoot formation (continued)

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
C-76-12-441	434980	6883475	440	0.00	0.00	0.36	0.02	0.00	0.06	0	600
C-76-12-509	434980	6883475	342	0.00	0.00	0.36	0.00	0.00	0.03	0	1200
C-76-12-756	434980	6883475	436	0.01	0.57	0.39	0.01	1.46	0.67	85	58
C-76-14-057	433950	6889920	431	0.01	0.18	0.48	0.07	0.38	0.13	138	369
C-76-14-066	433950	6889920	434	0.03	0.39	1.53	0.07	0.25	0.82	48	187
C-76-14-077	433950	6889920	429	0.03	0.36	1.50	0.07	0.24	0.76	47	197
C-76-14-080	433950	6889920	437	0.02	0.32	2.03	0.06	0.16	0.71	45	286
C-76-14-090	433950	6889920	431	0.02	0.30	1.71	0.07	0.18	0.64	47	267
C-76-14-097	433950	6889920	435	0.02	0.28	1.35	0.07	0.21	0.52	54	260
C-76-14-105	433950	6889920	436	0.08	2.66	2.45	0.03	1.09	2.71	99	90
C-76-14-111	433950	6889920	437	0.05	0.57	1.81	0.08	0.31	1.16	50	156
C-76-14-124	433950	6889920	430	0.05	0.62	0.92	0.08	0.67	1.19	52	77
C-76-14-132	433950	6889920	435	0.07	1.85	1.88	0.04	0.98	2.25	84	84
C-76-14-143	433950	6889920	440	0.15	9.37	1.13	0.02	8.29	6.63	143	17
C-76-14-146	433950	6889920	428	0.29	28.25	1.73	0.01	16.33	13.54	209	13
C-76-14-154	433950	6889920	440	0.02	0.75	1.62	0.03	0.46	1.08	70	150
C-76-14-156	433950	6889920	439	0.03	0.68	1.54	0.04	0.44	1.11	62	139
C-76-14-162	433950	6889920	429	0.06	1.95	0.54	0.03	3.61	2.07	95	26
C-76-14-174	433950	6889920	440	0.11	1.00	1.76	0.10	0.57	1.60	63	110
C-76-14-175	433950	6889920	434	0.06	1.05	1.61	0.05	0.65	1.66	63	97
C-76-14-185	433950	6889920	423	0.07	0.52	0.58	0.12	0.90	0.44	118	132
C-76-16-150	434265	6184310	487	0.14	1.88	0.67	0.07	2.81	3.07	62	22
C-76-16-177	434265	6184310	463	0.11	2.04	0.32	0.05	6.38	2.79	75	11
GL03-2A	429657	6904616	447	0.15	0.78	1.72	0.16	0.45	2.44	32	70
GL03-3B	429524	6904655	461	0.03	0.48	0.69	0.06	0.70	1.32	37	52
GL03-5A	429668	6904864	442	0.19	1.74	0.94	0.10	1.85	2.47	71	38
GL03-5C	429668	6904864	439	0.21	4.96	1.32	0.04	3.76	3.70	135	36
GL03-5D	429668	6904864	439	0.80	22.30	0.60	0.03	37.17	5.71	391	11
GL03-9A	429948	6905297	489	0.02	0.15	0.90	0.13	0.17	0.64	23	141
GL03-10C	428392	6912139	-40	0.00	0.00	2.01	0.00	0.00	1.82	0	110
GL03-13D	460022	6893977	-40	0.00	0.00	1.12	1.00	0.00	0.92	0	122
GL03-17B	455988	6877573	513	0.00	0.00	0.83	0.38	0.00	0.38	0	218
GL03-18B	455718	6877707	501	0.00	0.06	0.84	0.01	0.07	0.74	8	114
GL03-20B	441298	6886202	535	0.00	0.18	0.98	0.01	0.18	2.71	7	36
GL03-20D	441298	6886202	545	0.00	0.14	1.39	0.02	0.10	2.66	6	52
GL03-22A	441748	6885861	549	0.00	0.11	0.52	0.03	0.21	1.79	7	29
GL03-22C	441748	6885861	526	0.01	0.21	0.40	0.03	0.53	2.65	9	15
GL03-22E	441748	6885861	524	0.00	0.01	1.12	0.21	0.01	0.82	1	137
GL03-22J	441748	6885861	537	0.00	0.08	2.06	0.04	0.04	2.05	4	100
GL03-23A	436456	6888383	508	0.00	0.10	0.96	0.00	0.10	1.10	9	87
GL03-23D	436456	6888383	512	0.00	0.26	1.36	0.00	0.19	1.92	14	71
GL03-23F	436456	6888383	508	0.00	0.32	1.27	0.00	0.25	1.84	17	69

Tanglefoot formation (continued)

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
GL03-24E	434006	6890664	443	0.01	2.12	3.52	0.00	0.60	3.54	61	99
GL03-30C	431042	6908305	-40	0.00	0.00	0.76	1.00	0.00	0.41	0	185
GL03-30D	431042	6908305	-40	0.00	0.00	0.85	1.00	0.00	0.38	0	224
GL03-30E	431042	6908305	-40	0.00	0.00	0.77	1.00	0.00	0.52	0	148
GL03-39A	436777	6908818	-40	0.00	0.00	1.39	0.00	0.00	0.61	0	228
GL03-44B	441092	6861315	605	0.00	0.93	12.63	0.00	0.07	44.46	3	28
GL03-44C	441092	6861315	-40	0.00	0.00	0.96	0.00	0.00	0.52	0	185
GL03-45A	439319	6865677	474	0.00	0.38	1.90	0.00	0.20	1.25	31	152
GL03-45E	439319	6865677	463	0.01	0.27	0.48	0.02	0.56	0.91	31	53
GL03-68B	455245	6877903	465	0.00	0.07	0.52	0.00	0.13	0.44	16	118
GL03-69A	466405	6809300	508	0.03	0.04	0.29	0.47	0.14	0.98	4	30
GL03-69E	466405	6809300	513	0.00	0.12	0.60	0.01	0.20	1.02	13	59
GL03-69EE	466405	6809300	510	0.01	0.42	0.91	0.02	0.46	2.75	16	33
GL03-70A	466134	6809925	500	0.00	0.01	0.11	0.07	0.09	0.33	3	33
GL03-70B	466134	6809925	507	0.01	0.07	0.24	0.07	0.29	0.84	8	29
GL03-70C	466134	6809925	509	0.00	0.09	0.14	0.02	0.64	0.85	11	16
GL03-73A	442488	6860181	-40	0.00	0.00	0.03	1.00	0.00	0.05	0	60
GL03-73B	442488	6860181	-40	0.00	0.00	0.03	1.00	0.00	0.13	0	23
GL03-75A	442204	6801621	444	0.00	0.12	0.18	0.00	0.67	0.64	19	28
GL03-75C	442204	6801621	437	0.00	0.03	0.49	0.02	0.06	0.35	9	140
GL03-78C	454918	6829145	-40	0.00	0.00	0.26	1.00	0.00	0.09	0	289
GL03-91G	464396	6803479	-40	0.00	0.00	0.50	1.00	0.00	0.51	0	98
GL03-95B	463534	6806068	-40	0.00	0.00	1.16	1.00	0.00	0.21	0	552
GL03-97B	463713	6805770	-40	0.00	0.00	1.13	1.00	0.00	0.42	0	269
GL03-97C	463713	6805770	-40	0.00	0.00	1.14	1.00	0.00	0.27	0	422
GL03-99B	470476	6797182	-40	0.00	0.00	0.64	0.00	0.00	0.50	0	128
GL03-100A	475575	6790537	456	0.10	6.98	0.65	0.01	10.74	6.86	103	9
GL03-100C	475575	6790537	469	0.03	0.18	0.88	0.13	0.20	0.57	32	154
GL03-102B	481339	6777628	-40	0.00	0.00	0.31	0.00	0.00	0.49	0	63
GL03-103A	481560	6777390	548	0.00	0.00	0.17	0.00	0.00	0.79	0	22
GL04-64B	463503	6802692	407	0.00	0.00	0.34	0.01	0.00	0.07	0	486
GL04-102B	513914	6790104	606	0.01	0.01	0.53	0.31	0.02	1.76	1	30
GL04-102D	513914	6790104	598	0.00	0.00	0.27	0.05	0.00	0.69	0	39
GL04-102E	513914	6790104	606	0.02	0.04	0.40	0.32	0.10	2.69	2	15
GL04-103B	513341	6789935	553	0.02	0.10	0.40	0.12	0.25	2.11	5	19
94-25-20	441900	6801798	432	0.02	1.50	0.40	0.01	3.75	1.66	92	24
94-25-163	441900	6801798	428	0.02	1.63	0.28	0.01	5.82	1.39	118	20
94-38-28	444410	6799580	434	0.00	1.16	0.20	0.00	5.80	1.23	95	16
94-38-69	444410	6799580	446	0.09	3.59	0.27	0.03	13.30	3.16	115	9
94-38-150	444410	6799580	430	0.11	4.25	0.43	0.02	9.88	4.76	90	9
94-38-154	444410	6799580	427	0.12	5.13	0.40	0.02	12.83	4.01	128	10
94-38-161	444410	6799580	428	0.08	3.84	0.32	0.02	12.00	3.37	115	9

Tanglefoot formation (continued)

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
94-38-172	444410	6799580	425	0.16	9.33	0.39	0.02	23.92	5.02	186	8
94-40-262	444409	6799579	424	0.25	17.59	0.57	0.01	30.86	5.01	351	11
94-40-267	444409	6799579	429	0.15	5.94	0.41	0.02	14.49	3.49	170	12
94-42-253	444189	6799726	423	0.04	3.74	0.64	0.01	5.84	1.98	189	32
94-42-259	444189	6799726	426	0.05	4.23	0.33	0.01	12.82	3.02	140	11
94-47-98	442860	6801040	432	0.02	1.90	0.29	0.01	6.55	1.25	153	23
94-47-175	442860	6801040	605	0.03	0.08	0.21	0.23	0.38	1.81	5	12
94-47-199	442860	6801040	436	0.04	2.48	0.47	0.01	5.28	1.47	169	32
94-47-218	442860	6801040	426	0.13	9.36	0.63	0.01	14.86	3.86	243	16
94-47-219	442860	6801040	432	0.06	2.97	0.40	0.02	7.43	3.58	84	11
97-61-79	444703	6797233	434	0.05	2.33	0.31	0.02	7.52	2.21	106	14
97-61-207	444703	6797233	434	0.04	3.00	0.33	0.01	9.09	2.21	137	15
97-61-229	444703	6797233	409	0.01	0.03	0.85	0.21	0.04	0.06	50	1417
97-63-83	445122	6796798	428	0.11	7.75	0.47	0.01	16.49	4.35	180	11

Tantalus Formation

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
C-76-01-108	434000	6889070	435	0.04	2.93	1.90	0.01	1.54	4.44	67	43
C-76-01-126	434000	6889070	427	0.01	0.14	1.08	0.04	0.13	0.51	27	212
C-76-01-127	434000	6889070	443	0.01	0.03	1.49	0.25	0.02	0.17	18	876
C-76-01-132	434000	6889070	425	0.01	0.23	1.63	0.04	0.14	0.76	30	214
C-76-01-139	434000	6889070	441	0.01	0.04	0.52	0.17	0.08	0.23	17	226
C-76-01-197	434000	6889070	432	0.01	0.34	2.03	0.03	0.17	0.71	48	286
C-76-01-327	434000	6889070	449	0.00	0.06	1.07	0.04	0.06	0.45	13	238
C-76-01-331	434000	6889070	431	0.00	0.09	1.08	0.04	0.08	0.48	19	225
C-76-01-339	434000	6889070	440	0.01	0.06	1.57	0.15	0.04	0.30	20	523
C-76-01-404	434000	6889070	435	0.01	0.14	0.87	0.07	0.16	0.41	34	212
C-76-01-405	434000	6889070	437	0.00	0.01	1.37	0.20	0.01	0.06	17	2283
C-76-01-614	434000	6889070	433	0.02	1.90	0.76	0.01	2.50	1.88	102	40
C-76-01-620	434000	6889070	434	0.02	0.26	1.11	0.06	0.23	0.38	68	292
C-76-01-668	434000	6889070	437	0.00	0.68	0.86	0.01	0.79	0.94	73	91
C-76-01-685	434000	6889070	472	0.00	0.02	0.32	0.05	0.06	0.12	17	267
C-76-01-690	434000	6889070	446	0.00	0.02	0.37	0.00	0.05	0.19	11	195
C-76-01-751	434000	6889070	434	0.01	1.13	0.62	0.01	1.82	1.34	85	46
C-76-01-754	434000	6889070	440	0.00	0.12	0.42	0.01	0.29	0.26	46	162
C-76-01-761	434000	6889070	436	0.01	1.61	0.43	0.01	3.74	1.71	95	25
C-76-01-774	434000	6889070	433	0.00	0.34	0.36	0.01	0.94	0.45	76	80
C-76-01-793	434000	6889070	435	0.00	0.61	0.44	0.01	1.39	1.19	52	37
C-76-01-796	434000	6889070	437	0.01	0.44	0.36	0.02	1.22	0.48	92	75
C-76-01-810	434000	6889070	439	0.01	1.37	0.81	0.01	1.69	2.65	53	31
C-76-02-001	434000	6889070	439	0.02	1.02	1.53	0.02	0.67	1.50	69	102
C-76-02-050	434000	6889070	433	0.06	3.94	1.13	0.02	3.49	3.30	120	34
C-76-02-059	434000	6889070	441	0.01	0.15	0.63	0.04	0.24	0.31	48	203
C-76-02-060	434000	6889070	434	0.00	0.19	0.54	0.02	0.35	0.54	35	100
C-76-02-114	434000	6889070	438	0.02	1.75	0.73	0.01	2.40	1.95	91	37
C-76-02-143	434000	6889070	429	0.01	0.81	2.39	0.02	0.34	2.18	38	110
C-76-02-171	434000	6889070	456	0.00	0.04	1.59	0.05	0.03	0.27	15	589
C-76-02-174	434000	6889070	432	0.02	1.19	0.98	0.01	1.21	1.67	72	59
C-76-02-189	434000	6889070	436	0.00	0.09	0.99	0.05	0.09	0.42	21	236
C-76-02-205	434000	6889070	434	0.01	1.37	0.48	0.01	2.85	1.69	82	28
C-76-02-207	434000	6889070	440	0.02	2.70	1.73	0.01	1.56	4.23	65	41
C-76-02-215	434000	6889070	444	0.01	0.11	1.26	0.05	0.09	0.43	26	293
C-76-02-221	434000	6889070	434	0.00	0.11	0.39	0.02	0.28	0.30	37	130
C-76-02-277	434000	6889070	449	0.03	1.22	2.54	0.03	0.48	2.08	60	122
C-76-02-279	434000	6889070	438	0.01	0.74	1.07	0.01	0.69	1.36	55	79
C-76-02-421	434000	6889070	435	0.02	3.27	0.57	0.01	5.74	3.39	97	17
C-76-02-632	434000	6889070	442	0.03	5.21	1.02	0.01	5.11	4.96	107	21
C-76-02-660	434000	6889070	431	0.02	1.73	0.56	0.01	3.09	2.05	85	27
C-76-02-768	434000	6889070	437	0.03	2.31	0.40	0.01	5.78	1.70	137	24

Tantalus formation (continued)

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
C-76-02-814	434000	6889070	434	0.02	2.19	0.37	0.01	5.92	2.04	108	18
C-76-03-043	433900	6889920	441	0.01	0.63	2.01	0.01	0.31	1.76	37	114
C-76-03-045	433900	6889920	432	0.01	0.37	2.02	0.02	0.18	1.10	34	184
C-76-03-263	433900	6889920	445	0.02	0.63	2.38	0.03	0.26	1.77	36	134
C-76-03-273	433900	6889920	441	0.02	1.18	2.54	0.01	0.46	1.96	61	130
C-76-05-060	433900	6889920	438	0.00	0.15	1.16	0.03	0.13	0.71	21	163
C-76-05-065	433900	6889920	429	0.00	0.05	0.71	0.08	0.07	0.30	17	237
C-76-05-077	433900	6889920	441	0.00	0.39	1.90	0.01	0.21	1.34	30	142
C-76-05-078	433900	6889920	445	0.00	0.09	1.35	0.05	0.07	0.53	17	255
C-76-05-090	433900	6889920	441	0.01	0.10	0.47	0.07	0.21	0.34	29	138
C-76-05-093	433900	6889920	445	0.00	0.02	1.56	0.08	0.01	0.31	6	503
C-76-05-101	433900	6889920	490	0.00	0.00	1.68	0.00	0.00	0.23	0	730
C-76-05-104	433900	6889920	446	0.00	0.01	1.81	0.29	0.01	0.13	8	1392
C-76-05-107	433900	6889920	444	0.01	0.04	1.48	0.24	0.03	0.35	11	423
C-76-05-652	433900	6889920	438	0.01	0.40	0.45	0.01	0.89	0.69	58	65
C-76-05-750	433900	6889920	431	0.01	1.23	0.57	0.01	2.16	1.35	91	42
C-76-05-855	433900	6889920	440	0.01	1.92	0.38	0.00	5.05	1.69	115	22
C-76-05-858	433900	6889920	435	0.01	2.52	0.75	0.00	3.36	2.39	106	31
C-76-05-878	433900	6889920	440	0.01	2.04	0.54	0.01	3.78	2.02	102	27
C-76-05-883	433900	6889920	438	0.01	1.74	0.47	0.01	3.70	1.93	91	24
C-76-05-916	433900	6889920	423	0.00	0.30	0.33	0.01	0.91	1.00	30	33
C-76-05-942	433900	6889920	437	0.01	1.59	0.53	0.01	3.00	1.68	96	32
C-76-08-488	434080	6890040	430	0.02	1.22	0.58	0.01	2.10	1.30	95	45
C-76-08-500	434080	6890040	428	0.01	0.21	0.34	0.03	0.62	0.19	111	179
C-76-10-212	434785	6883720	470	0.01	0.33	2.57	0.04	0.13	1.30	26	198
C-76-10-529	434785	6883720	446	0.01	0.14	1.86	0.06	0.08	0.61	23	305
C-76-10-666	434785	6883720	468	0.02	0.31	0.44	0.05	0.70	1.28	25	34
C-76-10-747	434785	6883720	437	0.05	1.85	4.82	0.03	0.38	5.16	37	93
C-76-10-786	434785	6883720	453	0.01	1.53	0.67	0.01	2.28	2.62	60	26
C-76-10-801	434785	6883720	463	0.03	1.65	1.12	0.02	1.47	2.55	66	44
C-76-10-861	434785	6883720	479	0.00	0.69	0.51	0.01	1.35	1.28	55	40
C-76-11-087	434120	6888920	433	0.01	0.56	2.44	0.02	0.23	1.33	43	183
C-76-11-099	434120	6888920	454	0.00	0.01	1.25	0.30	0.01	0.04	25	3125
C-76-11-106	434120	6888920	444	0.00	0.07	1.32	0.01	0.05	0.38	18	347
C-76-11-108	434120	6888920	445	0.00	0.04	0.46	0.02	0.09	0.24	17	192
C-76-11-163	434120	6888920	437	0.03	1.55	0.56	0.02	2.77	1.49	105	38
C-76-11-210	434120	6888920	444	0.01	0.51	1.46	0.03	0.35	1.21	43	121
C-76-11-242	434120	6888920	442	0.00	0.05	1.21	0.09	0.04	0.37	14	327
C-76-11-261	434120	6888920	445	0.01	0.26	1.36	0.04	0.19	0.80	33	170
C-76-11-274	434120	6888920	435	0.01	0.08	1.25	0.10	0.06	0.45	18	278
C-76-11-278	434120	6888920	435	0.01	0.19	1.03	0.07	0.18	0.49	39	210
C-76-11-284	434120	6888920	434	0.01	0.21	1.17	0.02	0.18	0.53	40	221

Tantalus formation (continued)

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
C-76-11-445	434120	6888920	434	0.01	0.48	0.68	0.01	0.71	0.54	89	126
C-76-11-470	434120	6888920	445	0.07	1.83	1.59	0.04	1.15	2.94	64	54
C-76-11-490	434120	6888920	435	0.03	0.45	0.34	0.07	1.32	0.73	63	47
C-76-11-496	434120	6888920	435	0.02	2.45	0.49	0.01	5.00	2.50	99	20
C-76-11-512	434120	6888920	439	0.03	1.62	0.73	0.02	2.22	1.75	94	42
C-76-11-519	434120	6888920	435	0.05	0.35	0.77	0.13	0.45	0.63	56	122
C-76-11-520	434120	6888920	436	0.00	0.10	0.83	0.03	0.12	0.40	25	208
C-76-11-524	434120	6888920	438	0.01	0.09	1.61	0.11	0.06	0.32	28	503
C-76-11-528	434120	6888920	434	0.00	0.23	0.79	0.02	0.29	0.51	45	155
C-76-11-586	434120	6888920	437	0.03	2.76	0.55	0.01	5.02	2.77	101	20
C-76-11-649	434120	6888920	434	0.01	1.25	0.53	0.01	2.36	1.37	92	39
C-76-11-650	434120	6888920	439	0.01	0.99	0.87	0.01	1.14	1.23	81	71
C-76-11-653	434120	6888920	434	0.03	1.47	0.64	0.02	2.30	1.69	88	38
C-76-11-666	434120	6888920	443	0.00	0.04	0.46	0.03	0.09	0.28	14	164
C-76-11-675	434120	6888920	441	0.01	0.51	0.29	0.02	1.76	0.61	85	48
C-76-11-680	434120	6888920	434	0.00	0.77	0.31	0.00	2.48	0.82	94	38
C-76-11-699	434120	6888920	438	0.02	3.93	0.72	0.00	5.46	4.80	83	15
C-76-11-707	434120	6888920	440	0.00	0.43	0.33	0.01	1.30	0.85	52	39
C-76-11-709	434120	6888920	430	0.00	0.21	0.50	0.01	0.42	0.52	40	96
C-76-11-744	434120	6888920	437	0.00	0.63	0.45	0.00	1.40	0.87	74	52
C-76-11-773	434120	6888920	433	0.01	0.46	0.25	0.03	1.84	0.67	69	37
C-76-11-817	434120	6888920	439	0.01	0.55	0.30	0.01	1.83	0.76	72	39
C-76-11-821	434120	6888920	439	0.01	1.02	0.27	0.01	3.78	1.21	85	22
C-76-11-827	434120	6888920	434	0.00	0.08	0.20	0.01	0.40	0.15	53	133
C-76-13-068	434445	6884315	525	0.01	0.01	0.92	0.64	0.01	0.11	9	836
C-76-13-402	434445	6884315	471	0.01	0.03	0.38	0.15	0.08	0.11	27	345
C-76-13-487	434445	6884315	471	0.01	0.24	0.44	0.04	0.55	0.45	53	98
C-76-13-544	434445	6884315	465	0.02	0.25	0.40	0.06	0.63	0.39	64	103
C-76-13-609	434445	6884315	459	0.01	0.08	0.35	0.09	0.23	0.13	62	269
C-76-14-235	433950	6889920	436	0.03	0.40	2.09	0.07	0.19	1.15	36	182
C-76-14-247	433950	6889920	430	0.18	6.44	1.94	0.03	3.32	4.12	157	47
C-76-14-256	433950	6889920	440	0.21	19.18	1.45	0.01	13.23	5.68	339	26
C-76-14-260	433950	6889920	432	0.06	0.57	0.71	0.09	0.80	0.65	88	109
C-76-14-270	433950	6889920	431	0.06	1.09	0.52	0.05	2.10	1.12	98	46
C-76-14-273	433950	6889920	436	0.02	0.14	0.92	0.12	0.15	0.20	70	460
C-76-14-429	433950	6889920	438	0.02	0.50	1.02	0.03	0.49	0.61	82	167
C-76-14-430	433950	6889920	441	0.02	0.81	1.37	0.02	0.59	1.15	71	119
C-76-14-452	433950	6889920	435	0.03	1.24	0.36	0.02	3.44	1.04	120	35
C-76-14-455	433950	6889920	432	0.04	1.93	0.77	0.02	2.51	1.94	101	40
C-76-14-466	433950	6889920	438	0.01	0.28	0.62	0.04	0.45	0.34	82	182
C-76-14-502	433950	6889920	432	0.01	0.09	0.27	0.11	0.33	0.13	69	208
C-76-14-504	433950	6889920	429	0.02	0.28	0.33	0.05	0.85	0.40	70	83

Tantalus formation (continued)

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
C-76-14-510	433950	6889920	440	0.01	0.43	1.56	0.02	0.28	0.93	47	168
C-76-14-523	433950	6889920	430	0.02	0.57	0.29	0.04	1.97	0.90	63	32
C-76-14-589	433950	6889920	434	0.02	0.11	0.25	0.12	0.44	0.12	92	208
C-76-14-600	433950	6889920	432	0.02	0.84	0.34	0.03	2.47	1.21	69	28
C-76-14-601	433950	6889920	448	0.03	2.88	0.67	0.01	4.30	3.70	79	18
C-76-15-106	434070	6888500	430	0.05	1.00	2.24	0.05	0.45	1.92	53	117
C-76-15-111	434070	6888500	440	0.03	0.73	2.17	0.04	0.34	1.49	50	146
C-76-15-253	434070	6888500	434	0.07	2.93	1.02	0.02	2.87	3.07	96	33
C-76-15-257	434070	6888500	466	0.02	0.38	0.67	0.05	0.57	1.34	29	50
C-76-15-282	434070	6888500	437	0.03	1.56	0.33	0.02	4.73	1.26	125	26
T1-7 14.0	450400	6798400	452	0.01	0.08	2.45	0.15	0.03	0.21	38	1167
T9-5 192.3	439400	6703200	449	0.00	0.01	0.65	0.34	0.02	0.08	13	813
T9-9 452.0	439400	6703200	431	0.00	0.01	0.40	0.10	0.03	0.04	25	1000
T9-10 467.7	439400	6703200	402	0.03	0.10	0.45	0.25	0.22	0.06	167	750
T9-11 486.0	439400	6703200	436	0.01	0.04	0.90	0.22	0.04	0.12	33	750
T9-28 1179.2	439400	6703200	430	0.10	1.03	1.28	0.08	0.80	1.06	97	121
T9-30 1280.0	439400	6703200	437	0.03	1.12	2.20	0.02	0.51	1.68	67	131
T11-7 63.9	480600	6867600	458	0.01	0.15	0.65	0.07	0.23	0.54	28	120
T11-8 72.7	480600	6867600	487	0.02	0.22	0.89	0.07	0.25	0.62	35	144
T11-11 157.0	480600	6867600	339	0.02	0.02	0.99	0.50	0.02	0.12	17	825
T12-4	480500	6867500	344	0.02	0.06	0.32	0.29	0.19	0.10	60	320
T12-41	480500	6867500	577	0.02	0.03	0.27	0.33	0.11	0.39	8	69
T12-43	480500	6867500	520	0.01	0.29	1.29	0.04	0.22	1.12	26	115
T12-46	480500	6867500	482	0.04	0.41	0.39	0.08	1.05	0.94	46	41
T12-50	480500	6867500	368	0.02	0.05	0.29	0.34	0.17	0.11	45	264
T13-2 1.0	434300	6890300	443	0.02	0.35	0.69	0.05	0.51	0.80	44	86
T13-3 3.7	434300	6890300	438	0.05	3.48	3.36	0.01	1.04	4.89	72	69
T13-6 7.1	434300	6890300	435	0.05	1.57	2.42	0.03	0.65	2.91	55	83
T13-11 9.8	434300	6890300	424	0.13	0.34	1.15	0.27	0.30	0.25	136	460
T13-12 10.1	434300	6890300	436	0.04	0.57	1.31	0.06	0.44	1.13	51	116
T13-13 10.5	434300	6890300	435	0.06	1.36	1.26	0.04	1.08	2.27	61	56
T13-22 16.3	434300	6890300	436	0.04	0.64	0.83	0.06	0.77	1.22	53	68
T17-1 0.0	433800	6885200	309	0.32	0.24	0.26	0.57	0.92	0.15	160	173
T17-4 1.5	433800	6885200	359	0.04	0.10	0.41	0.26	0.24	0.11	91	373
T17-10 75.3	433800	6885200	327	0.81	2.12	0.79	0.28	2.68	0.55	385	144
T17-12 181.5	433800	6885200	452	0.11	0.70	2.77	0.14	0.25	1.29	55	215
T17-32 297.7	433800	6885200	441	0.05	0.14	1.25	0.29	0.11	0.49	29	255
T18-6 32.0	432900	6883400	335	0.03	0.07	0.27	0.32	0.26	0.13	54	208
T19-4 10.0	484700	6706900	515	0.00	0.02	0.73	0.15	0.03	0.34	6	215
T19-13 65.0	484700	6706900	336	0.01	0.03	0.51	0.22	0.06	0.21	14	243
T19-46 123.5	484700	6706900	521	0.01	0.05	2.12	0.20	0.02	2.12	2	100
T19-60 224.0	484700	6706900	334	0.00	0.00	0.46	0.50	0.00	0.03	0	1533

Tantalus formation (continued)

Sample	Easting	Northing	T_{max}	S1	S2	S3	PI	S2/S3	TOC	HI	OI
T20-7 3.0	485800	6705900	348	0.01	0.04	0.34	0.21	0.12	0.05	80	680
T22-22	495700	6686100	497	0.00	0.00	0.38	0.78	0.00	0.25	0	152
GL03-24A	434006	6890664	437	0.01	0.96	1.18	0.01	0.81	1.63	60	72
GL03-24B	434006	6890664	447	0.00	0.73	2.22	0.00	0.33	1.83	40	121
GL03-24C	434006	6890664	440	0.00	1.86	2.58	0.00	0.72	3.03	62	85
GL03-46E	438192	6867931	473	0.00	0.00	0.16	0.02	0.00	0.25	0	64
GL03-58B	455535	6802395	513	0.00	0.09	1.67	0.00	0.05	1.32	7	127
GL03-59C	455484	6803101	491	0.01	0.21	1.40	0.06	0.15	1.13	19	124
GL03-60B	454797	6804082	492	0.05	0.27	1.31	0.15	0.21	1.48	19	89
GL03-60C	454797	6804082	509	0.01	0.03	0.78	0.27	0.04	0.47	6	166
GL03-63B	457911	6803958	508	0.00	0.08	0.52	0.00	0.15	0.57	14	91
GL03-64B	457738	6804139	491	0.02	0.13	0.42	0.16	0.31	0.84	15	50
GL03-64D	457738	6804139	488	0.02	0.09	0.18	0.15	0.50	0.58	16	31
GL03-65A	457985	6803864	491	0.04	0.12	0.32	0.24	0.38	0.65	18	49
GL03-67C	438047	6814323	444	0.11	1.20	1.29	0.08	0.93	2.66	46	48
GL03-67D	438047	6814323	440	0.00	0.24	1.33	0.00	0.18	2.44	10	55
GL03-67F	438047	6814323	426	0.00	0.76	0.70	0.00	1.09	2.61	30	27
97-63-28	445122	6796798	430	0.05	1.14	0.35	0.04	3.26	1.04	111	34