Report 20090401

A preliminary insight into the gas shale potential of the Amadeus and Georgina Basins, Australia

Vu Thi Anh Tiem
Brian Horsfield
Rolando di Primio

GeoS4 GmbH
Peter-Huchel-Chaussee 88
14552 Michendorf
Germany

Address: Telephone: Telefax: e-mail:	GeoS4 GmbH Peter-Huchel-Chaussee 88 14552 Michendorf Germany +49 3320523861 +49 3320523862 info@geos4.com
Report Number:	GeoS4 20090401
Report Title:	A preliminary insight into the gas shale potential of the Amadeus and Georgina Basins, Australia
Authors:	T.A.T. Vu, B. Horsfield, R. di Primio
Classification:	Confidential
Client:	Geoscience Australia
Client Reference:	Tom Bernecker
Distribution: Customer GeoS4 GmbH	 1 + CD 1 + CD

T.A.T. Vu | B. Horsfield | R. di Primio

List of Tables

List of Figures

1. Abstract

Twenty-four samples provided by Geoscience Australia were analysed using screening methods to provide a preliminary insight into the gas shale potential of the Amadeus and Georgina Basins, Australia. The eleven Amadeus samples include the Lower Giles Creek Member (Middle Cambrian), the Bitter Springs Formation (Late Proterozoic), the Goyder Formation (Late Cambrian- Early Ordovician) and the Horn Valley Siltstone (Early Ordovician). The thirteen core samples from Georgina Basin are from the Middle Cambrian, and most of them from the Arthur Creek Formation "hot shale".

Amadeus Basin - The Lower Giles Creek Member, the Bitter Springs Formation and the Goyder Formation are poor gas shale candidates based on the results reported here. While they are characterized by high Production Indices (PI) ranging from 0.24-0.50 (wt ratio), a generally positive signal for overmature gas shales, the organic carbon contents are very low (in the range 0.07 to 0.16%), as are remaining petroleum generating potentials (S2 yield is around 0.08-0.21 µg/g sample). Their free hydrocarbons as well as their pyrolysis products consist mainly of gases. A wide range of T_{max} values (287-490°C) simply reflects the broad and irregular shape of the S2 peaks, the samples all being overmature. The remaining gas yield potential of these samples is just around 15 (µg/g sample). Meanwhile, two samples (G006481 and G006482) belonging to the Horn Valley Siltstone exhibit high TOC (3.16-3.42%), moderate Production Index (PI ~ 0.2) and mid-oil-window maturity (T_{max} of 445-449°C). These two samples display low Hydrogen Index values but can still be classified by pyrolysis gas chromatography as containing marine organic matter (probably kerogen type II) because these samples belong to the paraffinic-naphthenic-aromatic low wax oil facies. The remaining gas yield potential of the two representative samples ranges between 1775-2486 (µg/g sample).

Georgina Basin - The Arthur Creek Formation (middle Cambrian) has high gas shale prospectivity as revealed from screening results of all samples in the Elkedra-3 well, and G006487 in the-Macintyre-1 well. These samples have a high content of organic matter (TOC = 5.34-12.2%) and Hydrogen Index value of ~ 60-80 (mg/g TOC). The T_{max} values in the range 467-474°C fulfil the minimum of 450°C for gas shale potential according to Jarvie et al. (2007). Additionally, the aforementioned samples contain an abundance of low molecular weight paraffins $<nC_{20}$ fulfilling an empirical prerequisite for gas shale candidates. Upon pyrolysis the Arthur Creek Formation samples produce products falling in the gas and condensate petroleum type facies. The total gas yield of aforementioned samples ranges from 1230 to 3170 (µg/g sample). There are two relatively immature Middle Cambrian Shale samples (G006491 and G006492) which have a very high petroleum potential (HI ~ 600 mg/g TOC) and high organic carbon content (TOC = 9.04-15.8%). Their pyrolysis compositions fall in the paraffinic-naphthenic-aromatic low wax oil field of Horsfield (1989), but close to the boundary with the gas and condensate field. These are likely to be excellent source rocks for conventional petroleum systems, as well as potentially excellent gas shales at high maturity levels. The gas yield of these two samples is up to 8700-20000 (µg/g sample).

2. Samples

Twenty-four samples originating from the Amadeus and Georgina Basins were made available for this study by Tom Bernecker of Geoscience Australia (Table 1).

The eleven cuttings and core samples from the Amadeus Basin were collected from seven different wells, including Dingo-1, Murphi-1, Orange-1, Mount Winter-2A, Tempe Vale-1, Tent Hill-1 and Rodinga-6. These samples include the Lower Giles Creek Member (Middle Cambrian), the Bitter Springs Formation (Late Proterozoic), the Goyder Formation (Late Cambrian- Early Ordovician) and the Horn Valley Siltstone (Early Ordovician) (Dyson and Marshall, 2007).

The thirteen core samples from the Georgina Basin were selected from the Macintyre-1, Baldwyn-1, BMR Mt Isa-1 and NTGS Elkadra-3 wells. They are of Middle Cambrian age (Boreham and Ambrose, 2007), most of them coming from the Arthur Creek Formation "hot shale".

3. Experimental details

3.1. Rock Eval analysis

Rock Eval analysis was performed on all samplesusing a Rock-Eval 6 instrument. TOC determination was performed on all samples using a LECO CS244 device. Internal standards were run in parallel and checked against the acceptable range.

ROCK EVAL TEMPERATURE PROGRAMME

Pyrolysis: 300°C (3 min.) at 25 °C/min. to 650 °C (0 min.)

The Rock-Eval/ TOC results of samples from both Amadeus and Georgina Basins are summarised in Table 2. The Rock-Eval chromatograms of Amadeus samples are shown in Figure 1a-b, those of Georgina Basin samples are illustrated in Figure 2a-c. The relationships of hydrogen index to oxygen index and to T_{max} value are shown in Figure 3 and Figure 4, respectively.

3.2. Thermovaporisation

Thermovaporisation was used to analyse free hydrocarbons in selected unheated samples and performed using the Quantum MSSV-2 Thermal Analysis System©. Milligram quantities of each sample were sealed in a glass capillary and heated to 300°C in the injector unit for 5 minutes. The tube was then cracked open using a piston device coupled with the injector, and the released volatile hydrocarbons analysed by gas chromatography.

The thermovaporisation results of selected samples are reported in Table 3. The chromatograms are shown in Figure 5a-d.

3.3. Pyrolysis gas chromatography

Pyrolysis gas chromatography was performed on selected samples using the Quantum MSSV-2 Thermal Analysis System©. Thermally extracted (300°C 10 minutes) whole rock samples were heated in a flow of helium, and products released over the temperature range 300-600°C (40K/min) were focussed using a cryogenic trap, and then analysed using a 50m x 0.32mm BP-1 capillary column equipped with a flame ionisation detector. The GC oven temperature was programmed from 40°C to 320°C at 8°C/minute. Boiling ranges (C_1, C_2-C_5, C_6-C_{14}, C_{15+}) and individual compounds (n-alkenes, n-alkanes, alkylaromatic hydrocarbons and alkylthiophenes) were quantified by external standardisation using n-butane. Response factors for all compounds were assumed the same, except for methane whose response factor was 1.1.

Pyrolysis gas chromatography results are summarised in Table 4 and 5a-b. The chromatograms are given in Figure 6a-e. The ternary diagrams for assessing phenol enrichment (Larter, 1984), petroleum type organofacies (Horsfield, 1989) and sulphur content (Eglinton et al., 1990; di Primio and Horsfield, 1996) are given in Figure 7-10. The remaining gas potential of investigated samples is given in Table 4 and Figure 11.

4. Results

4.1. Amadeus Basin

Bulk source rock characteristics

Total organic carbon contents and Rock Eval results are listed in Table 2. The Amadeus Basin samples can be divided into two groups based on these results (Group A and B, see Table 1). Samples in Group A (including G006473-G006478) come from the Lower Giles Creek Member, the Bitter Springs Formation and the Goyder Formation. They have very low organic carbon contents, in the range 0.07 to 0.16%. Group B comprises of the Horn Valley Siltstone samples including G006479-G006483. Group B is more enriched in organic carbon, its total organic carbon content range being 0.45 - 3.42%.

The Rock-Eval chromatograms of samples in Group A are characterized by relatively high S1 peaks and more or less "flattened", irregular S2 peaks (except sample G006478-Goyder Formation whose S2 peak appears as a bell-shape). The S2 peaks of samples in Group A (Figure 1a) vary in both size and shape, displaying multiple-lobed S2 peaks which are not symmetrical and have a shoulder or tail. These samples have high production indexes (PI, Table 2) ranging from 0.24-0.5 (wt ratio). Group A samples have low Hydrogen Indices (27-159 mg HC/g TOC) and particularly high Oxygen Indices (157-437 mg CO_2/g TOC), and a wide range of T_{max} values (287-490°C) attributable to the irregular shapes of the broad S2 peaks. In both the HI vs. OI (Figure 3, after Espitalié et al. 1977) and HI vs. T_{max} (Figure 4, after Espitalié et al. 1984) diagrams, these samples (short labels as 1-6) represent low petroleum generating potential.

Samples in Group B release more or less bell-shaped S2 peaks (Figure 1b) whose yields are between 0.22 and 12.08 mg/g sediment. Group B is characterized by lower production index values (0.17-0.24 wt ratio; Table 2) in comparison with that of samples in the Group A. These values do not approach the 0.7 value which Jarvie (2007) states is needed for high shale gas prospectivity, but gas loss from the provided samples cannot be ruled out, meaning that PI values are minima. Group B has higher Hydrogen Indices (62-353 mg HC/g TOC) and lower Oxygen Indices (8-73 mg CO2/g TOC) than those of Group A. In both the HI vs. OI (Figure 3) and the HI vs. T_{max} diagrams (Figure 4), the Group B samples abbreviated as 7-11 (Table 2) represent higher hydrocarbon generating potential. The T_{max} values of these samples fall in a narrower range, from 430-449°C.

These T_{max} values are not above the minimum (450°C according to Jarvie et al., 2007) for shale gas prospectivity. However, two samples G006481 and G6482 might have shale gas potential because of their high TOC (3.16-3.42%), moderate PI ~ 0.2 (although gases might be lost) and T_{max} of 445-449°C (close to the minimum 450°C cut-off).

Free Hydrocarbons

Thermovaporisation analysis run on three samples in Group A (G006473, G006475 and G006478) reveals that the free hydrocarbons consist mainly of gases. Meanwhile, the thermally extracted products from two samples in Group B (G006481, G006482) are comprised of mainly higher molecular weight alkanes including both normal and branched alkanes in range of C_9 to C_{19} and gaseous hydrocarbons. The odd-even predominance for the Horn Valley Siltstone is typical of many Ordovician source rocks and crude oils worldwide (Reed et al., 1986).

Bulk chemical composition from pyrolysis gas chromatography

The pyrolysis gas chromatograms of samples from Amadeus Basin are shown in Figure 6a-b. The pyrolysis boiling ranges and individual yields are given in Table 4-5.

Three samples in Group A were selected for pyrolysis gas chromatography analysis (Figure 6a). They included G006473 (Lower Giles Creek Member), G006475 (Bitter Spring Formation) and G006478 (Goyder Formation). These samples generate only gaseous hydrocarbons and benzene upon pyrolysis (Figure 6a). Their compositions fall in the gas and condensate facies of Horsfield (1989) as shown in Figure 8. The remaining gas generating potential yield of these samples is around 15 µg/g sample (Figure 11).

Two samples of Group B include G006481 and G006482, both from the Horn Valley Siltstone. Upon pyrolysis, these two samples produce a mixture of aliphatic hydrocarbons and aromatic hydrocarbons (benzene and toluene). Doublets extend to medium chain length (C_{15}) and decrease in relative abundance with increasing carbon number from C_6 to C_{15}, which is typical for type II kerogen (van de Meent et al., 1980; Muscio et al., 1993; Clegg et al., 1997). The pyrolysis compositions of these samples fall in type II intermediate sulphur enrichment field of Eglinton et al. (1990) and of di Primio and Horsfield (1996) as illustrated in Figure 9-10. The kerogen structure is phenol-poor according to the diagram of Larter (1984; Figure 7). The petroleum type is defined as Paraffinic-Naphthenic-Aromatic Low Wax Oil based on the ternary diagram of Horsfield (1989; Figure 8), though the Horn Valley Siltstone may have started out in the Low Wax Paraffinic Facies at lower maturity (Horsfield, 1989). Their present-day compositions (especially the

pyrolysate composition of G006482) are very close to the boundary with the gas condensate field. The remaining gas generating potentials of G006481 and G006482 are 2486 and 1775 µg/g sample respectively.

4.2. Georgina Basin

Bulk source rock characteristics

Total organic carbon content and Rock Eval results are listed in Table 2. Samples from the Georgina Basin have high organic carbon contents, mainly in the range 5.34 to 15.8%. There are three samples having lower organic carbon contents. They are G006484-G006485 (1.23 and 1.01 respectively) from the Macintyre-1 and sample G006493 (0.5%) from the BMR Mt Isa-1.

The Rock-Eval chromatograms of the Georgina Basin samples (except for the three samples G006491-G006493 originating from the BMR Mt Isa-1 well - see Table 1) shown in Figure 2a-c are characterized by significant S1 peaks and the multiple lobed S2 peaks, since they are not symmetrical and have a shoulder or tail. These samples have moderate to high Production Indices (PI, Table 2) ranging from 0.12- 0.37 (wt ratio). These values do not approach the 0.7 value Jarvie (2007) states is needed for high shale gas prospectivity, but gas loss from the provided samples cannot be ruled out. Hydrogen Indices of the aforementioned samples are low and range from 22 to 101 mg HC/g TOC. Oxygen Indices ranging from 3 to 23 (CO_2/g TOC) are relatively low. In the HI vs. OI (Figure 3, after Espitalié et al. 1977) and HI vs. T_{max} (Figure 4, after Espitalié et al. 1984) diagrams, these samples (short labelled as 12-18 and 22-24) are at the end of the mean evolution pathways. Their T_{max} values of 457-586°C are above 450°C, the minimum for shale gas prospectivity according to Jarvie et al. (2007).

Three samples from the BMR Mt Isa-1 well release relatively small S1 peaks in comparison with their respective S2 peaks, and the latter are bell-shaped (Figure 2b). These samples are characterized by very low Production Indices, which range from 0.03-0.05 (wt ratio). The Hydrogen Index values of 330-620 (mg/g TOC) are high. According to Figure 3 and 4, it shows that two samples including G006491 and G006492, whose total organic carbon contents of 9.04-15.8%, fall between the mean evolutionary paths of kerogen type I and II. Clearly, these are very good potential source rocks for petroleum, both conventional and, at higher maturity levels, unconventional. Meanwhile, sample G006493, which has much lower TOC value (0.5%), can be classified as mixture of kero-

gen type II and III representing lower petroleum generating potential. T_{max} values in range of 428-433°C show these samples to be immature.

Free Hydrocarbons

The volatile products released upon thermal extraction of G006484 from the Macintyre-1 comprises of gaseous hydrocarbons and normal plus branched alkanes in range of C_{12}-C_{22}.

The volatile product of the sample G006487 reveals an n-alkane envelope in the low molecular weight range (< nC_{19}), an empirical prerequisite for high productivity according to Jarvie et al. (2007). The same holds true for three samples from the Elkadra-3 well, which release paraffins below nC_{20} upon thermovaporisation (Figure 5c-d). Sample G006495 also produces a relatively large unresolved complex mixture (Figure 5d).

In the case of sample G006489 (Baldwyn-1) its thermovaporisation products are dominated by gas and condensate components.

Bulk chemical composition from pyrolysis gas chromatography

The pyrolysis gas chromatograms of samples from Georgina Basin are shown in Figure 6b-e. Boiling ranges and individual compound yields are given in Table 4-5.

Two samples from the Macintyre-1 well were selected for pyrolysis gas chromatographic analysis (Figure 6b-c), these being G006484 and G006487 from the Arthur Creek Formation (Middle Cambrian). The pyrolysis gas chromatograms of these two samples are characterized by the predominance of gaseous hydrocarbons. The aromatic hydrocarbons include benzene and toluene appear as significant peaks in gas chromatograms. Doublets are found in lower abundance extending to C_{22}. Phenolic compounds have also been found. The composition of samples from the Macintyre-1 well falls in the kerogen type II field of Eglinton et al. (1990; Figure 9) and of di Primio and Horsfield (1996; Figure 10). The kerogen structure can be relatively enriched in phenol as revealed from the diagram of Larter (1984; Figure 7). The petroleum type can be classified as gas condensate according to Horsfield (1989; Figure 8). The total remaining gas generating potential is ~300-1200 (µg/g sample; Tab. 4 and Figure 11).

The gas chromatogram of sample G006489 (Baldwyn-1 well) comprises a mixture of gaseous hydrocarbons and aromatic compounds (benzene and toluene). Its petroleum

type is defined as gas condensate according to the plot of Horsfield (1989; Figure 8). The remaining gas generating potential of this sample is ~ 740 (µg/g sample).

Two samples (G006491 and G006492) from the BMR Mt Isa-1 well, which have high Hydrogen Index values of 600-620 (mg/g TOC) and T_{max} ~ 430°C, produce a mixture of aliphatic- and aromatic hydrocarbons up on pyrolysis. Methane appears as a significant peak in the chromatograms. Phenols and sulphur-compounds make only a small contribution. Doublets extend to C_{24} and decrease in relative abundance with increasing carbon number, which is typical for marine kerogen (van de Meent et al., 1980; Muscio et al., 1993; Clegg et al., 1997). The presence of 1,2,3,4-tetramethylbenzene (TeMB), eluting between the nC_{11} and nC_{12} doublets, is suggestive of photic zone euxinia during deposition (Muscio et al., 1994). The pyrolysis compositions of these two samples fall in the type II field of Eglinton et al. (1990), in the type II intermediately enriched in sulphur field of di Primio and Horsfield (1996), and the phenol poor field of Larter (1984). Their petroleum types are defined as paraffinic-naphthenic-aromatic low wax oil (Horsfield, 1989). Their compositions are very close to the boundary with the gas condensate field (Figure 8). They have the highest remaining gas generating potential yields (between 8679 and ~20000 µg/g sample) among the investigated samples, as illustrated in Figure 11. It is clear that while this source rock (Middle Cambrian Shale) has a very high petroleum potential (HI ~ 600 mg/g TOC), this potential is manifested by the light hydrocarbon predominance throughout the liquid window. The ability to generate light hydrocarbons predominantly at low stages of thermal evolution might be an important characteristic of high quality gas shales in general.

The gas chromatograms of three samples from the NTGS Elkadra-3 are shown in Figure 6d-e. They all generate significant amount of gaseous hydrocarbons and aromatic compounds. Doublets in the range of C_{10}-C_{20} make a less contribution. The presence of 1,2,3,4-tetramethylbenzene (TeMB) indicates the photic zone anaxia during deposition (Muscio et al., 1994). These samples can be defined as a mixture of kerogen type II and III (Figure 9) enriched in aromatics (Figure 10). They could be moderately enriched in phenol (Figure 7). The pyrolysis composition falls in the gas condensate field of Horsfield (1989). Remaining gas generating potential yield is around 2500-3100 (µg/g sample) and shown in Figure 11.

5. Conclusions

Twenty-four samples provided by Geosciences Australia were analysed using screening methods to evaluate the gas shale potential for source rocks in the Amadeus and Georgian Basins, Australia.

Amadeus Basin

Group A

Screening analysis shows that samples from the Lower Giles Creek Member, the Bitter Springs Formation and the Goyder Formation all have very low organic carbon contents (in the range 0.07 to 0.16%) and low petroleum generating potential. These samples however are characterized by the high Production Indices ranging from 0.24-0.5 (wt ratio) and a wide range of T_{max} values (287-490°C). Thermovaporisation of three selected samples shows their free hydrocarbons are mainly gases. These samples generate only gaseous hydrocarbons and benzene on pyrolysis. Their compositions fall in the gas and condensate facies of Horsfield (1989). The remaining gas yield potential of these samples is around 15 (µg/g sample).

Group B

Samples belonging to the Horn Valley Siltstone have a relative higher organic richness (TOC = 0.35-3.42%) and petroleum potential (HI = 62-353 mg/g TOC) in comparison with samples from the Lower Giles Creek Member, the Bitter Springs Formation and the Goyder Formation. The T_{max} values range from 430-449°C.

Among these samples, there are two samples G006481 and G6482 might have gas shale potential because of their high TOC (3.16-3.42%), moderate production index (PI ~ 0.2) and T_{max} of 445-449°C (closely to the minimum of 450°C). These two samples can be classified as kerogen type II. Up on pyrolysis, these samples produce Paraffinic-Naphthenic-Aromatic Low Wax Oil. Importantly, their compositions are very close to the boundary with the gas condensate field. The remaining gas generating potential of G006481 and G006482 ranges from 1775-2486 (µg/g sample).

Georgian Basin

The Macintyre-1 well

Samples G006484 and G006485 have a TOC content of 1.23%, 1.01% and a hydrogen index of 101 and 84 (mg/g TOC) respectively. Meanwhile, two other samples (G006486 and G006487) have a higher organic carbon content of 5.34-8.65%. The hydrogen index value of these two last samples is around 70 (mg/g TOC). The T_{max} values range from 457-475°C for four samples in this well.

Sample G006484 releases gases and alkanes in range of C_{12}-C_{22} up on thermal extraction. Its pyrolysis product is classified as gas and condensate. Its total remaining gas generation potential amounts to 300 (µg/g sample), which is rather small compared to that of sample G006487 whose gas yield is 1230 (µg/g samples). Additionally, the staining fingerprint of sample G006487 comprises of paraffins bellow nC_{20} fulfilling an empirical prerequisite for its possibility to considered as a gas shale candidate.

The Baldwyn-1 well

Samples in this well have a high content of organic matter (TOC = 5.47-11%), Hydrogen Index in range of 22-34 (mg/g TOC) and a high T_{max} value (522-586°C). The free hydrocarbon fingerprint of sample G006489 is characterized by gaseous hydrocarbons and aromatic compounds. This sample produces gases up on pyrolysis gas chromatography. Its remaining gas generating potential is around 740 (µg/g sample).

The BMR Mt Isa-1 well

Three samples from the BMR Mt Isa-1 well are characterized by very low production indexes (0.03-0.05 wt ratio), but high organic carbon content (TOC = 0.5-15.8%) and high petroleum generating potential (HI ~ 330-620 mg/g TOC). These samples can be classified as mixture of kerogen type II and III with T_{max} values in range of 428-433°C.

Samples G006491 and G006492 (Middle Cambrian Shale) have a very high petroleum potential (HI ~ 600 mg/g TOC) and high organic carbon content (TOC = 9.04-15.8%). They generate petroleum enriched in light hydrocarbons, even at low stages of thermal evolution. Remaining primary gas potential is very high, up to 8700-20000 (µg/g sample). Based on that criteria, this source rock is worthy of serious consideration as a potential gas shale.

The NTGS Elkedra-3 well

Similar to samples from the Horn Valley-Amadeus Basin, samples from the NTGS Elkedra-3 well also fulfil the empirical criteria to be considered as gas shale candidate. They have high organic carbon content (TOC = 9.66-12.2%), hydrogen index values in range of 64-73 (mg/g TOC) and high T_{max} values (467-474°C).

It is supported by their volatile products including paraffins bellow nC_{20} up on thermal-vaporisation. However, sample G006495 produces relatively large unresolved complex mixtures that might cause its relatively lower gas flow rates according to Jarvie et al. (2007). Up on pyrolysis, the Arthur Creek Formation samples in the NTGS Elkedra-3 well produce gas condensate. Their total gas potential ranges from 2500-3100 (µg/g sample).

6. References

Boreham, C.J., Ambrose, G.J., (2007) in Munson TJ and Ambrose GJ (editors). Proceedings of the Central Australian Basins Symposium (CABS), Alice Springs, Northern Territory, 16-18 August, 2005. Northern Territory Geological Survey, Special Publication 2, 254-281.

Clegg, H., Horsfield, B., Stasiuk, L., Fowler, M., Vliex, M., (1997) Geochemical characterisation of organic matter in Keg River Formation (Elk point group, Middle Devonian), La Crete Basin, Western Canada. Organic Geochemistry, 26(11-12), 627-643.

di Primio, R., Horsfield, B., (1996) Predicting the generation of heavy oils in carbonate/evaporitic environments using pyrolysis methods. Organic Geochemistry Proceedings of the 17th International Meeting on Organic Geochemistry, 24(10-11), 999-1016.

Dyson, I.A., Marshall, T.R., (2007) in Munson TJ and Ambrose GJ (editors). Proceedings of the Central Australian Basins Symposium (CABS), Alice Springs, Northern Territory, 16-18 August, 2005. Northern Territory Geological Survey, Special Publication 2, 1-11.

Eglinton, T.I., Damsté, J.S.S., Kohnen, M.E.L., Leeuw, J.W.d., 1990. Rapid estimation of the organic sulphur content of kerogens, coals and asphaltenes by pyrolysis-gas chromatography. Fuel 69, 1394-1404.

Espitalie´, J., Laporte, J.L., Madec, M., Marquis, F., Leplat, P., Paulet, J., Boutefeu, A., (1977) Méthode rapide de caractérisation des roches mères de leur potentiel pétrolier et de leur degré d´ évolution. Rev. Inst. Fr. Pét., 32, 23-42.

Espitalie', J., Marquis, F., Barsony, I., (1984) Geochemical logging. In K.T. Voorheers (Ed.). Analytical pyrolysis techniques and applications.

Jarvie, D.V., Hill, R.J., Ruble, T.E., Pollastro, R.M., 2007. Unconventional shale gas systems: the Mississippian Barnett Shale of north-central Texas as one model for thermogenic shale gas assessment. AAPG Bulletin 91, 475-499.

Horsfield, B., Disko, U., Leistner, F., (1989) The micro-scale simulation of maturation: outline of a new technique and its potential applications. Geologische Rundschau, 78(1), 361-374.

Larter, S.R., (1984) Application of analytical pyrolysis techniques to kerogen characterization and fossil fuel exploration/ exploitation. In K.T. Voorheers (Ed.). Analytical Pyrolysis Techniques and Applications.

van de Meent, D., Brown, S.C., Philp, R.P., Simoneit, B.R.T., (1980) Pyrolysis-high resolution gas chromatography and pyrolysis gas chromatography-mass spectrometry of kerogens and kerogen precursors. Geochimica et Cosmochimica Acta, 44(7), 999-1013.

Muscio, G.P.A., Horsfield, B., Welte, D.H., (1994) Occurrence of thermogenic gas in the immature zone- implications from the Bakken insource reservouir system. Organic Geochemistry, 22, 461-476.

Reed, J., Illich, H.A. and Horsfield, B. (1986) Biochemical evolutionary significance of Ordovician oils and their source. In: Advances in Organic Geochemistry 1985. Edited by Leythaeuser, D. and Rullkötter, J., 347-358, Pergamon Journals, Oxford.

Table 1: Geological background of investigated samples from Amadeus and Georgina Basins, and analysis details

Samples	Short ID	Basin	Group	Well	Depth	Type	Formations	RE	ThermoVAP	PyGC
G006473	1	Amadeus		Dingo-1	7860'-7870'	cutting	Lower Giles Creek Member	1	1	1
G006474	2	Amadeus		Dingo-1	7740-7750´	cutting	Lower Giles Creek Member	1		
G006475	3	Amadeus	A	Murphi-1	1527 m	cutting	Bitter Springs Formation	1	1	1
G006476	4	Amadeus		Murphi-1	1272 m	cutting	Bitter Springs Formation	1		
G006477	5	Amadeus		Orange-1	4070'8"	core	Goyder Formation	1		
G006478	6	Amadeus		Orange-1	4072'	core	Goyder Formation	1	1	1
G006479	7	Amadeus		Mount Winter-2A	242.9 m	core	Horn Valley Siltstone	1		
G006480	8	Amadeus		Tempe Vale-1	404.65 m	core	Horn Valley Siltstone	1		
G006481	9	Amadeus	B	Tempe Vale-1	409.4 m	core	Horn Valley Siltstone	1	1	1
G006482	10	Amadeus		Tent Hill-1	1145.9 m	core	Horn Valley Siltstone	1	1	1
G006483	11	Amadeus		Rodinga-6	75.3 m	core	Horn Valley Siltstone	1		
G006484	12	Georgina		Macintyre-1	766.7 m	core	Arthur creek Formation	1	1	1
G006485	13	Georgina		Macintyre-1	782.6m	core	Arthur creek Formation	1		
G006486	14	Georgina		Macintyre-1	797.7 m	core	Arthur creek Formation	1		
G006487	15	Georgina		Macintyre-1	803.2 m	core	Arthur creek Formation	1	1	1
G006488	16	Georgina		Baldwyn-1	879.2 m	core	Arthur creek Formation	1		
G006489	17	Georgina		Baldwyn-1	883.8 m	core	Arthur creek Formation	1	1	1
G006490	18	Georgina		Baldwyn-1	887.7m	core	Arthur creek Formation	1		
G006491	19	Georgina		BMR Mt Isa-1	101.5 m	core	"Middle Cambrian Shale"	1		1
G006492	20	Georgina		BMR Mt Isa-1	107.45 m	core	"Middle Cambrian Shale"	1		1
G006493	21	Georgina		BMR Mt Isa-1	114.35 m	core	"Middle Cambrian Shale"	1		
G006494	22	Georgina		NTGS Elkedra-3	102.25 m	core	Arthur creek Formation	1	1	1
G006495	23	Georgina		NTGS Elkedra-3	110.25 m	core	Arthur creek Formation	1	1	1
G006496	24	Georgina		NTGS Elkedra-3	113.42 m	core	Arthur creek Formation	1	1	1

Table 2: TOC and Rock-Eval parameters

Samples	short-ID	Group	S1	S2	S3	Tmax	PP	PI	HI	OI	TOC
			mg/g sediment			°C	mg/g	wt ratio	mg/g TOC		%
G006473	1		0.15	0.21	0.36	490	0.36	0.42	159	273	0.13
G006474	2		0.05	0.08	0.36	489	0.13	0.38	68	305	0.12
G006475	3	A	0.04	0.08	0.29	429	0.12	0.33	63	230	0.13
G006476	4		0.07	0.15	0.37	324	0.22	0.32	96	236	0.16
G006477	5		0.02	0.02	0.32	287	0.04	0.50	27	437	0.07
G006478	6		0.05	0.16	0.19	450	0.21	0.24	132	157	0.12
G006479	7		0.16	0.60	0.24	435	0.76	0.21	134	54	0.45
G006480	8		0.11	0.53	0.23	442	0.64	0.17	98	43	0.54
G006481	9	B	3.02	12.08	0.26	444	15.10	0.20	353	8	3.42
G006482	10		1.80	6.98	0.24	449	8.78	0.21	221	8	3.16
G006483	11		0.07	0.22	0.26	430	0.29	0.24	62	73	0.35
G006484	12		0.73	1.24	0.28	457	1.97	0.37	101	23	1.23
G006485	13		0.47	0.85	0.22	475	1.32	0.36	84	22	1.01
G006486	14		1.23	6.40	0.50	469	7.63	0.16	74	6	8.65
G006487	15		1.68	3.50	0.28	473	5.18	0.32	66	5	5.34
G006488	16		0.33	1.30	0.27	522	1.63	0.20	24	5	5.47
G006489	17		0.53	2.45	0.41	586	2.98	0.18	22	4	11.00
G006490	18		0.51	3.74	0.29	531	4.25	0.12	34	3	10.90
G006491	19		2.02	56.02	1.69	431	58.04	0.03	620	19	9.04
G006492	20		4.53	94.95	2.85	428	99.48	0.05	601	18	15.80
G006493	21		0.07	1.65	0.37	433	1.72	0.04	330	74	0.50
G006494	22		1.92	8.38	0.38	472	10.30	0.19	73	3	11.50
G006495	23		1.57	7.58	0.33	467	9.15	0.17	78	3	9.66
G006496	24		1.47	7.86	0.41	474	9.33	0.16	64	3	12.20

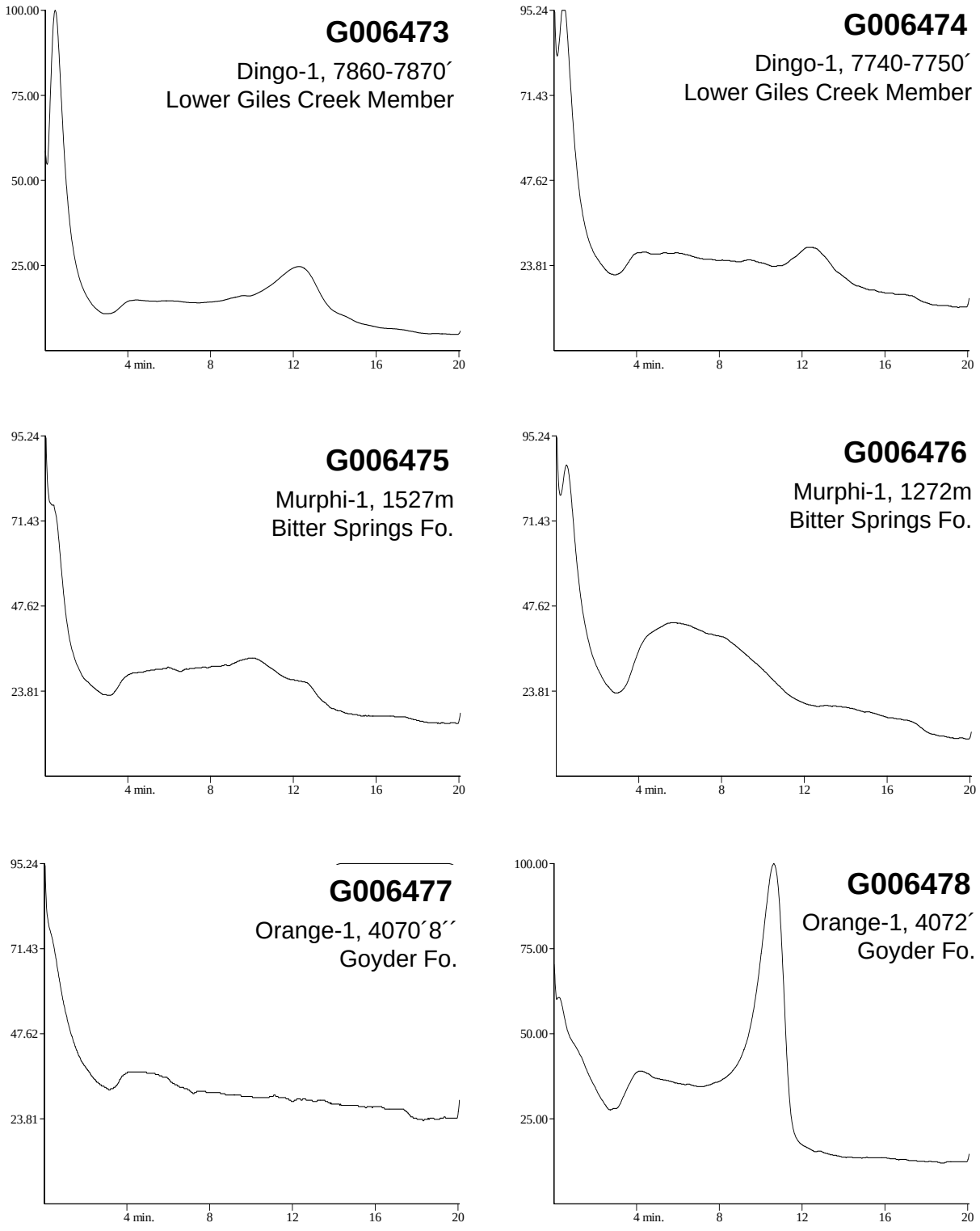


Figure 1a: The Rock-Eval chromatograms of samples in Group A originated from Amadeus Basin

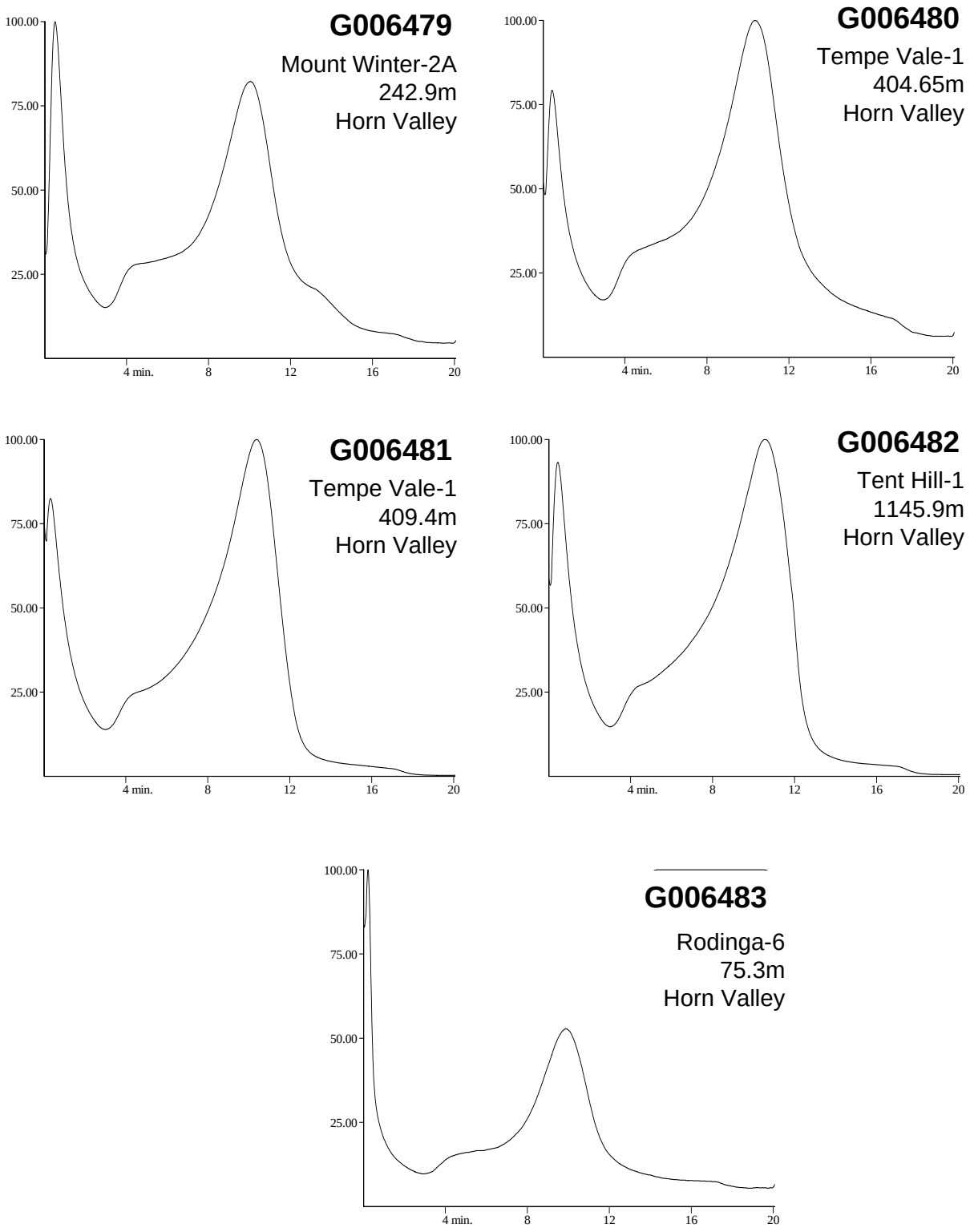


Figure 1b: The Rock-Eval chromatograms of Horn Valley samples (Group B) originated from Amadeus Basin.

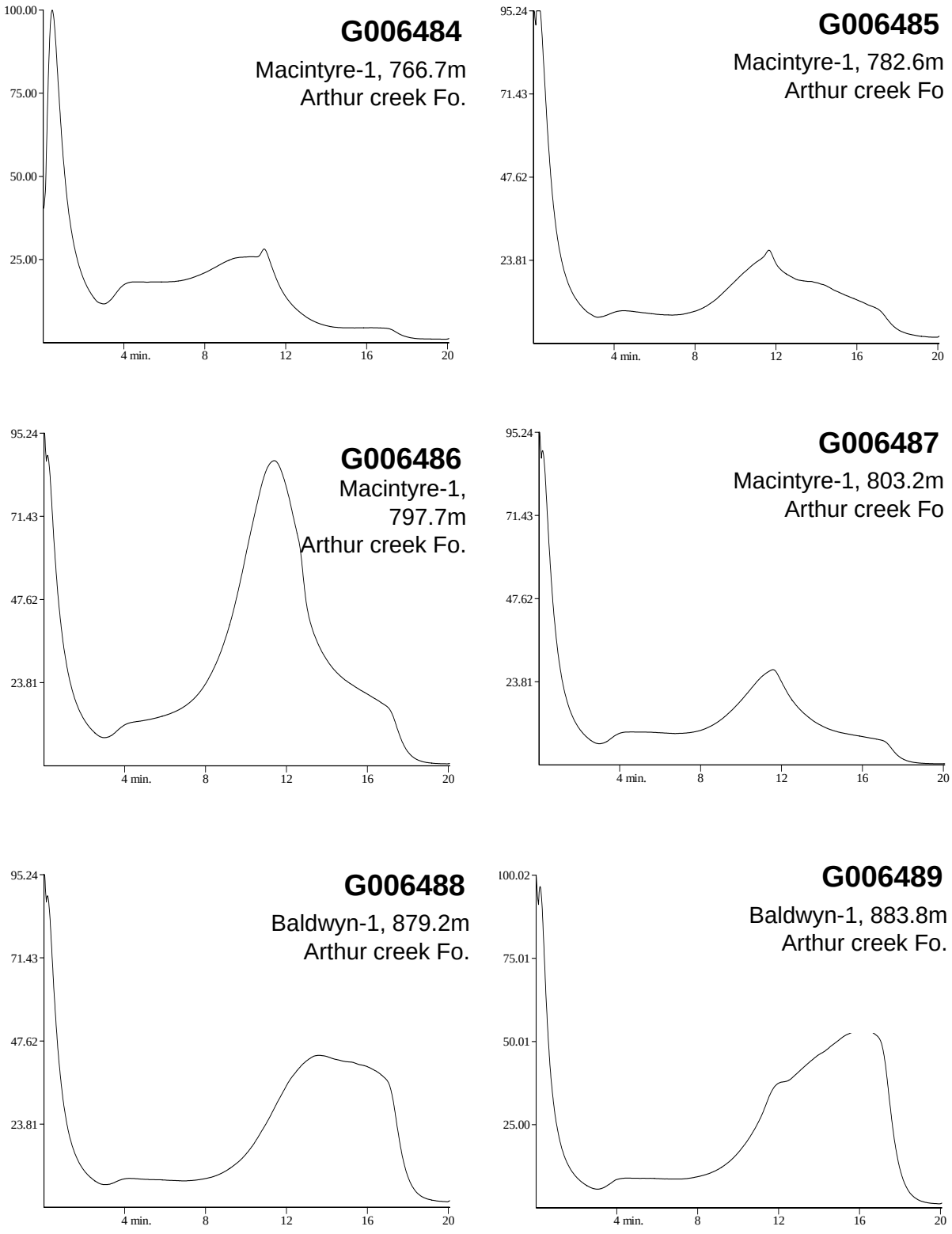


Figure 2a: The Rock-Eval chromatograms of samples originated from Georgina Basin

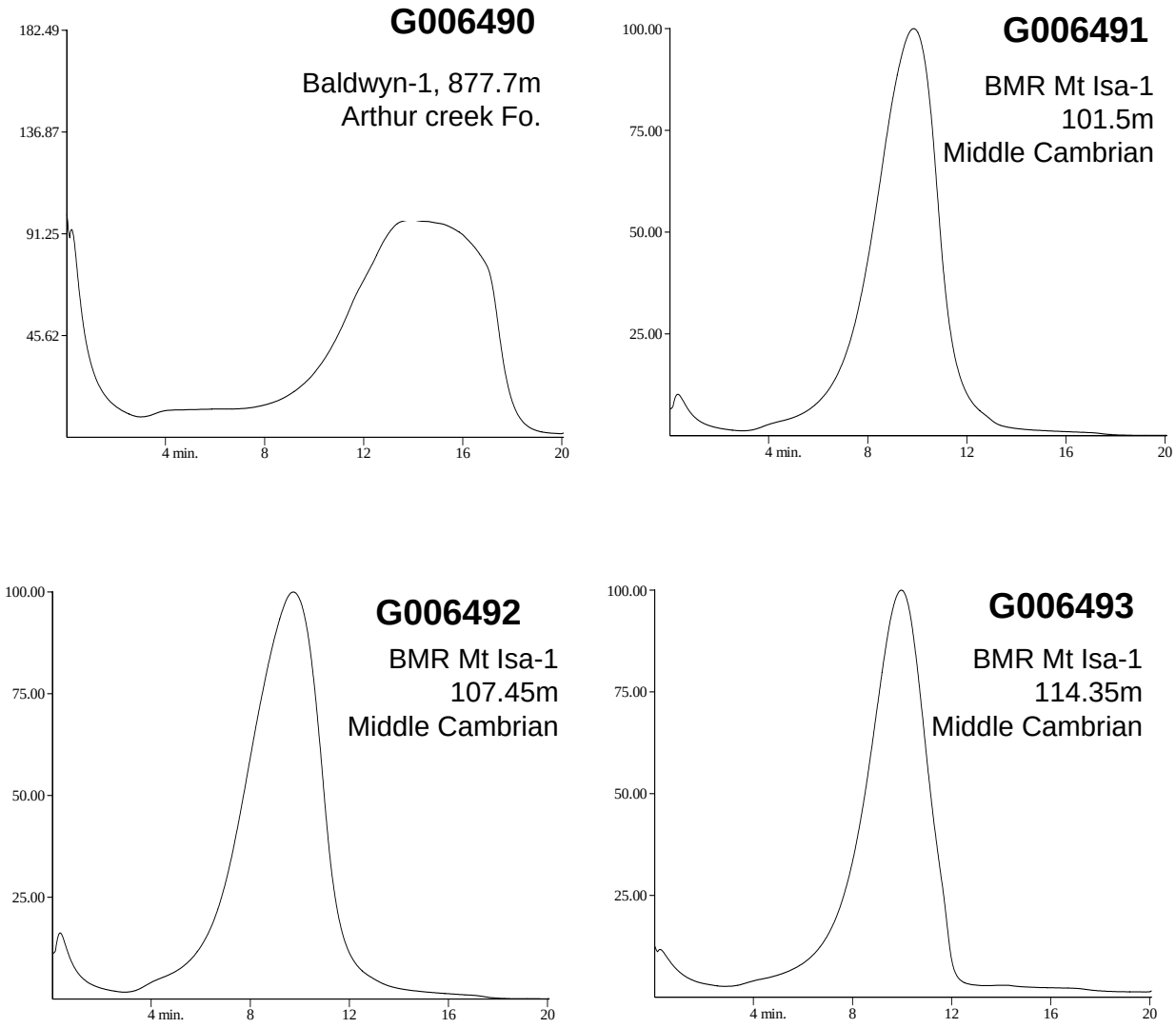


Figure 2b: The Rock-Eval chromatograms of samples originated from Georgina Basin (continued)

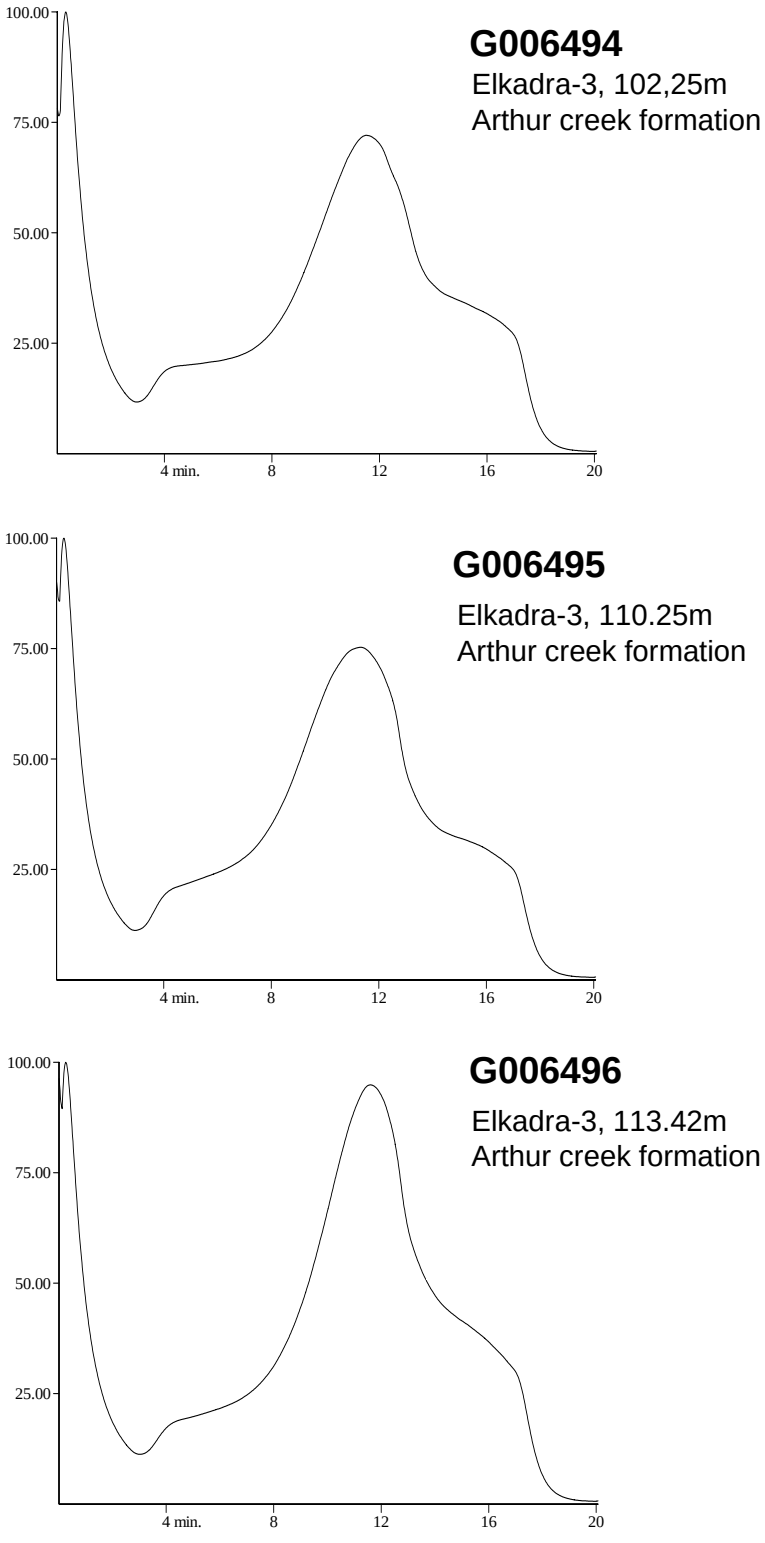


Figure 2c: The Rock-Eval chromatograms of samples originated from Georgina Basin (continued)

Figure 3: Hydrogen Index against Oxygen Index diagram after Espitalié et al., 1977. Numbers refer to the GeoS4 short-labels (see Table 1)

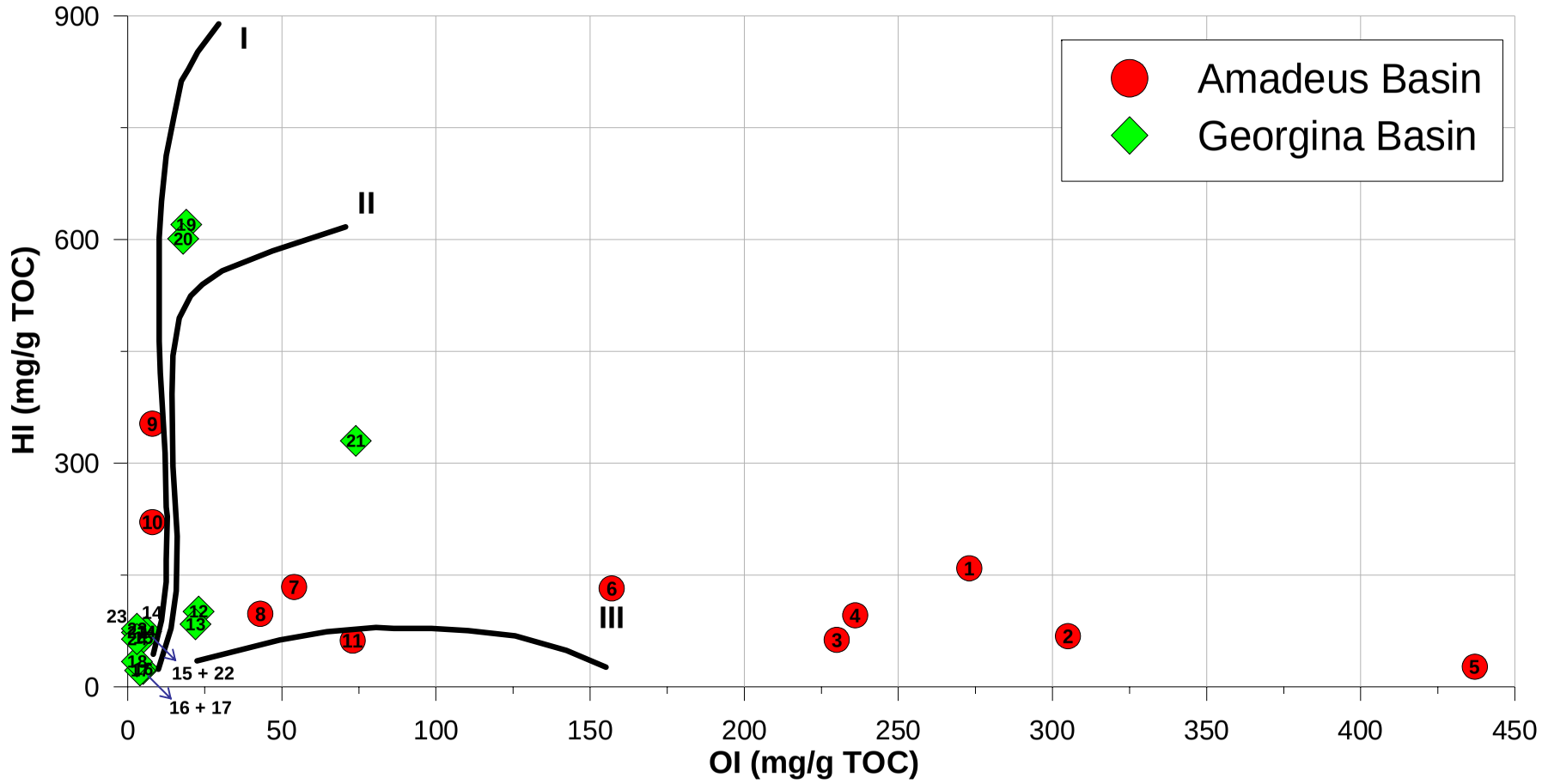
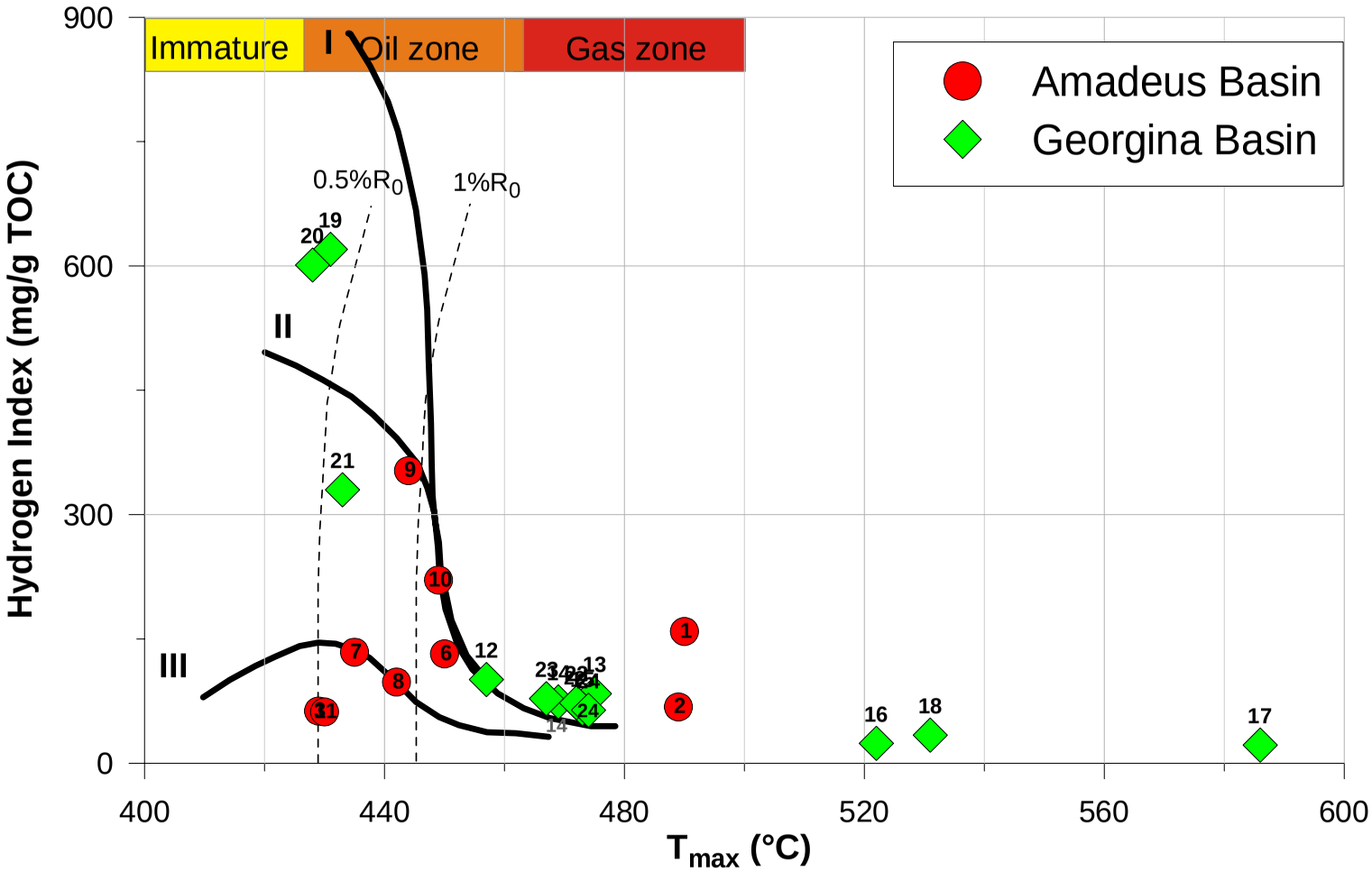


Figure 4: Hydrogen Index against Tmax diagram after Espitalié et al., 1984. Numbers refer to the GeoS4 short-labels (see Table 1)



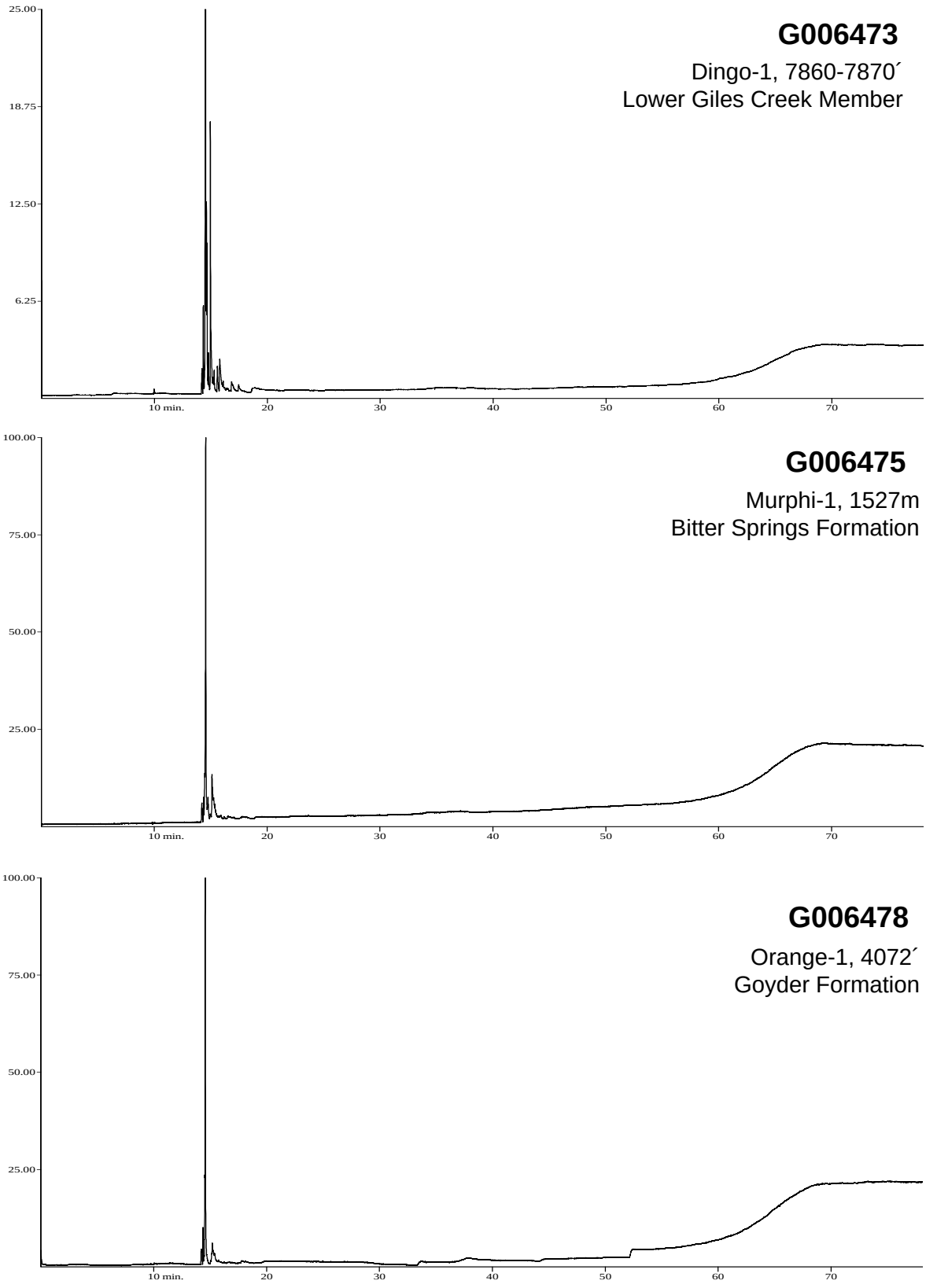


Figure 5a: Thermovaporisation chromatograms of samples G006473 (top), G006475 (middle) and G006478 (bottom).

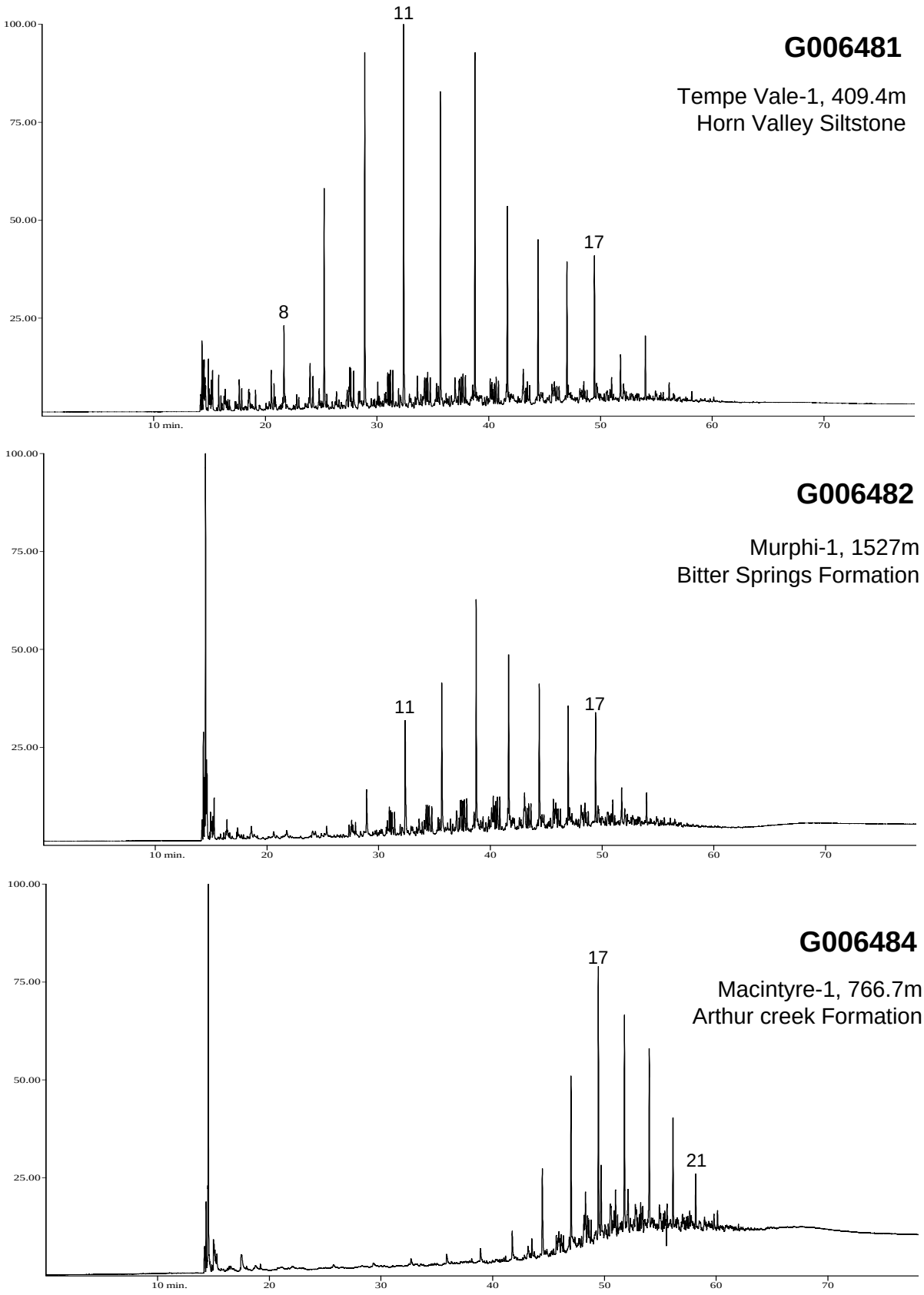


Figure 5b: Thermovaporisation chromatograms of samples G006481 (top), G006482 (middle) and G006484 (bottom). Numbers refer to chain length of n-alkene/-ane doublets.

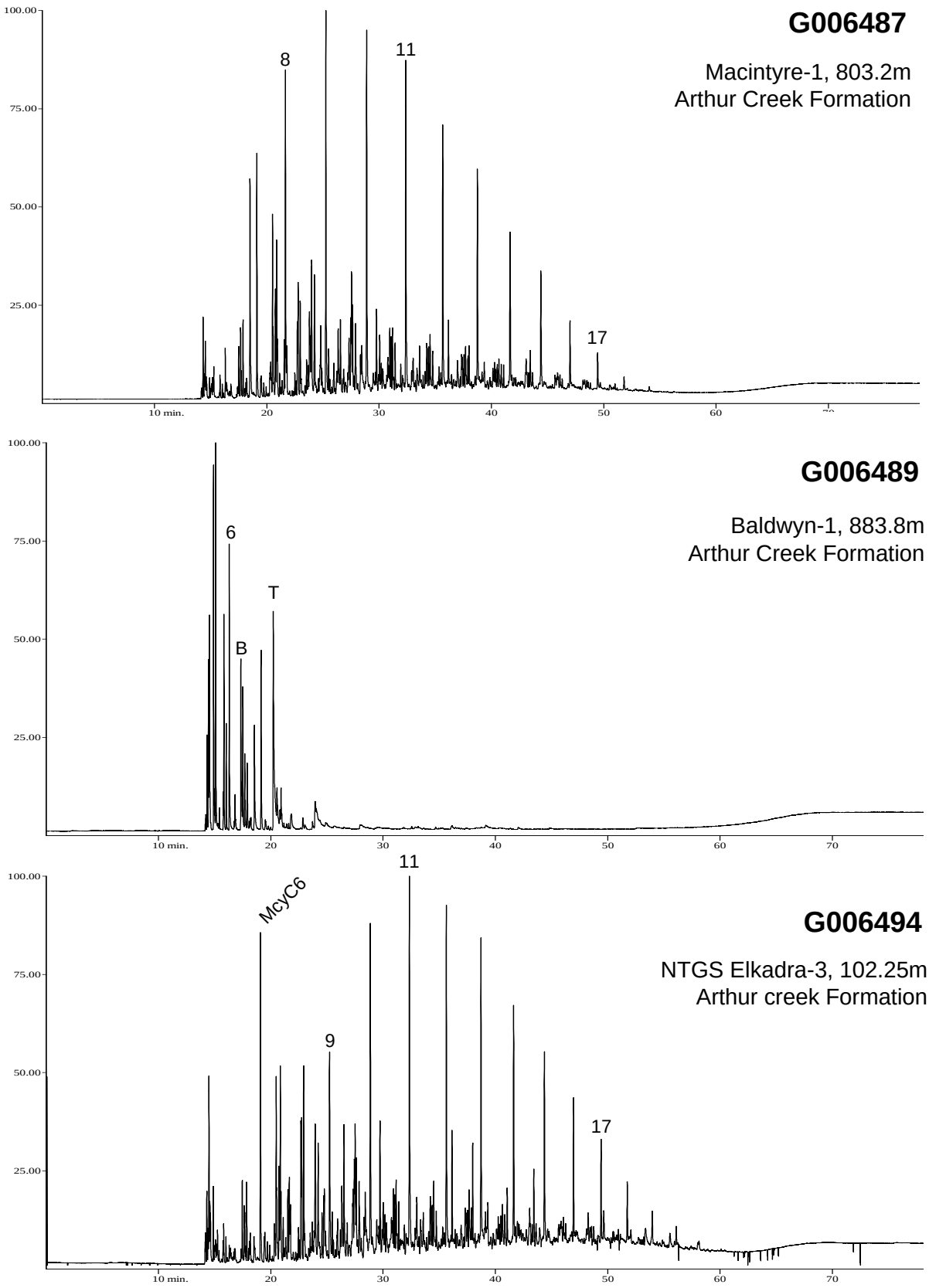


Figure 5c: Thermovaporisation chromatograms of samples G006487 (top), G006489 (middle) and G006494 (bottom). Numbers refer to chain length of n-alkene/-ane doublets. B = benzene, T = toluene, McyC6 = methylcyclohexane.

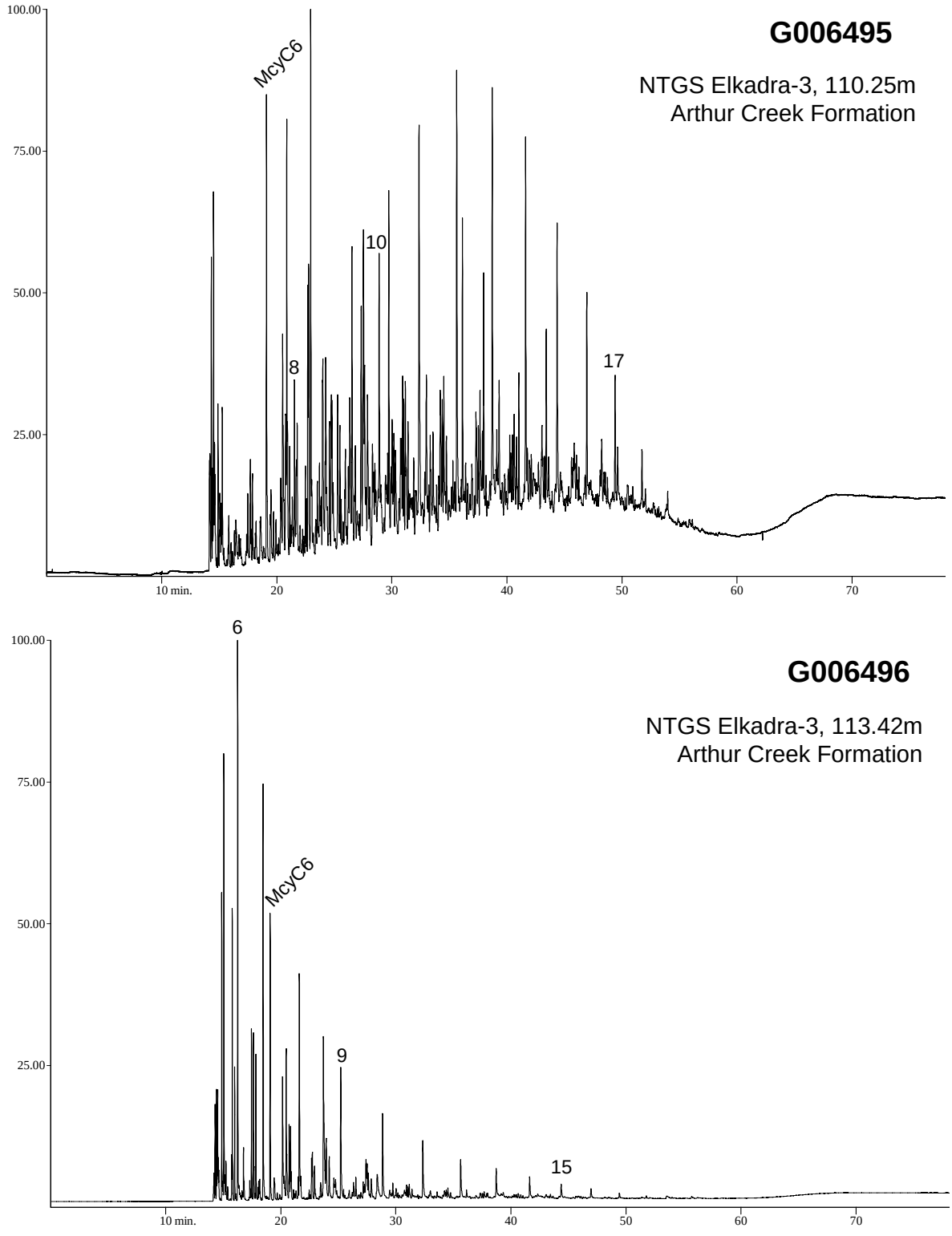


Figure 5d: Thermovaporisation chromatograms of samples G006495 (top) and G006496 (bottom). Numbers refer to chain length of n-alkene/-ane doublets. McyC6 = methylcyclohexane.

Table 3: The thermovaporisation individual yields and boiling ranges

Sample	G006473	G006475	G006478	G006481	G006482	G006484	G006487	G006489	G006494	G006495	G006496
(µg/g sample)											
C1*1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2	0.8	0.4	0.8	6.5	3.6	1.3	2.4	2.8	4.3	6.0	8.6
C3	1.5	0.1	0.2	19.0	13.9	1.3	8.8	10.2	6.3	8.3	22.8
iC4	0.8	0.4	1.3	10.3	5.3	0.2	2.1	13.7	1.9	1.5	18.7
nC4	34.9	7.1	5.8	15.3	46.5	10.8	7.6	27.2	16.9	10.5	28.3
C2-C5 Total	55.1	10.6	7.5	80.9	94.9	16.5	29.4	92.0	48.9	38.2	151.5
C6-14 Total (-Blank)	21.6	13.2	4.0	1937.3	754.3	98.3	1632.2	454.8	1454.6	1152.7	1719.0
C15_+ Total (-Blank)	0.0	0.0	0.0	1719.9	1003.6	525.1	467.6	13.2	846.7	655.9	228.5
C1-5 Total	55.2	10.7	7.5	80.9	94.9	16.5	29.4	92.0	48.9	38.2	151.5
C1-30+ Total (-Blank)	76.8	23.8	11.6	3738.1	1852.8	639.9	2129.3	560.0	2350.2	1846.8	2099.0
GOR Total	2.56	0.81	1.87	0.02	0.05	0.03	0.01	0.20	0.02	0.02	0.08
C6-C14 Resolved	10.5	2.6	1.9	1435.3	459.7	31.3	1232.4	396.1	1031.7	658.0	1427.9
C15+ Resolved	0.0	0.0	0.0	638.5	337.7	126.7	142.6	8.5	244.6	148.2	79.6
C1-30 Resolved	65.7	13.2	9.5	2154.7	892.3	174.5	1404.5	496.6	1325.1	844.3	1659.0
GOR Resolved	5.23	4.13	3.94	0.04	0.12	0.10	0.02	0.23	0.04	0.05	0.10
(µg/g TOC)											
C1*1.1	0	0	0	0	0	0	0	0	0	0	0
C2	606	329	676	191	115	104	44	26	37	62	70
C3	1152	70	207	556	441	103	164	92	55	86	187
iC4	593	312	1064	300	168	13	39	125	17	16	153
nC4	26882	5451	4792	449	1470	882	142	248	147	108	232
C2-C5 Total	42398	8162	6259	2366	3005	1338	551	837	425	395	1242
C6-14 Total (-Blank)	16615	10130	3367	56647	23870	7990	30566	4134	12649	11933	14090
C15_+ Total (-Blank)	0	0	0	50290	31759	42695	8757	120	7362	6790	1873
C1-5 Total	42461	8197	6283	2366	3005	1338	551	837	425	395	1242
C1-30+ Total (-Blank)	59076	18327	9650	109302	58634	52023	39874	5091	20436	19118	17205
C6-C14 Resolved	8112	1987	1597	41968	14549	2544	23080	3601	8971	6811	11704
C15+ Resolved	0	0	0	18670	10685	10305	2670	77	2127	1535	652
C1-30 Resolved	50573	10184	7880	63003	28239	14188	26301	4515	11523	8741	13598

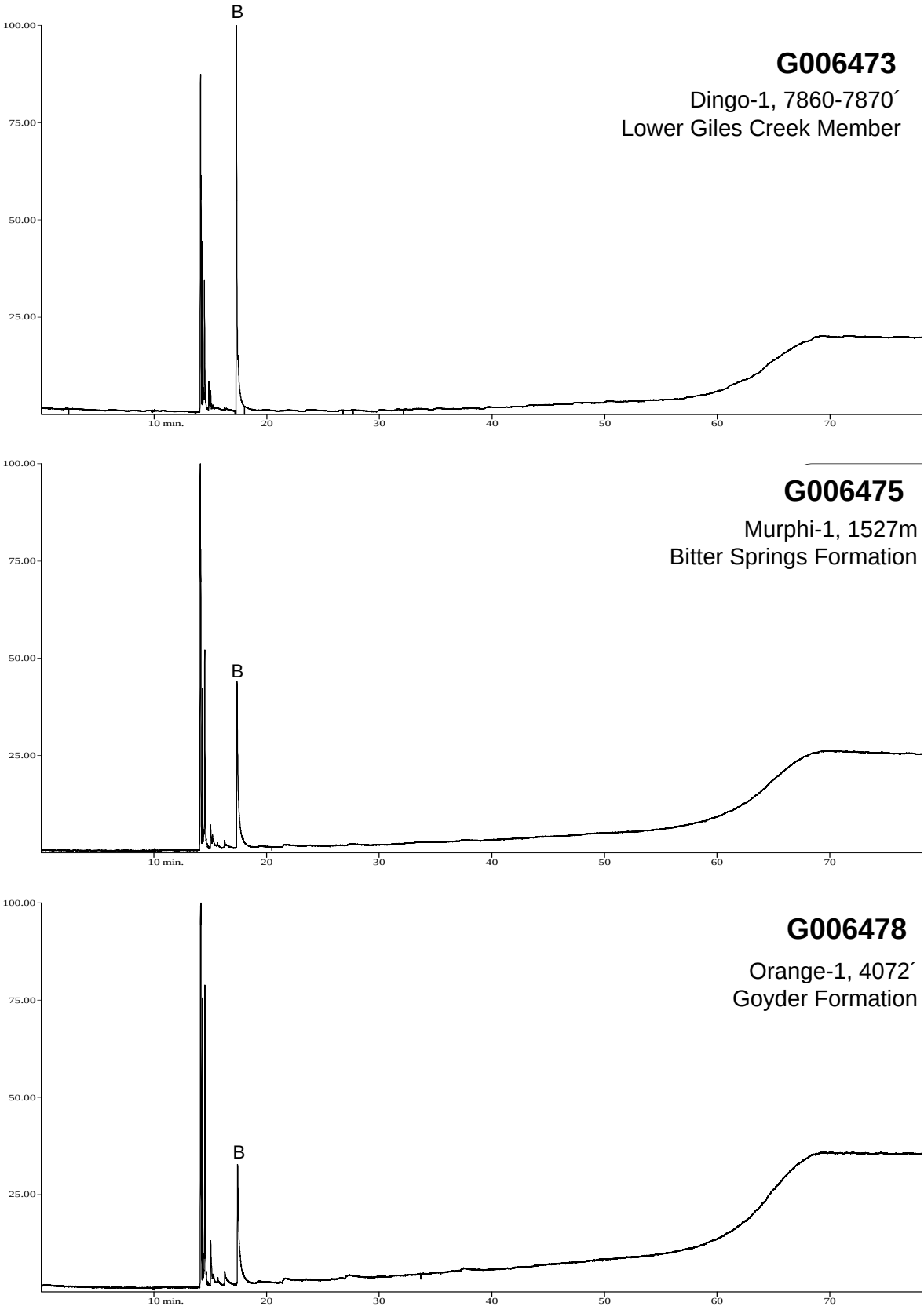


Figure 6a: Pyrolysis gas chromatograms of samples G006473 (top), G006475 (middle) and G006478 (bottom). B = benzene.

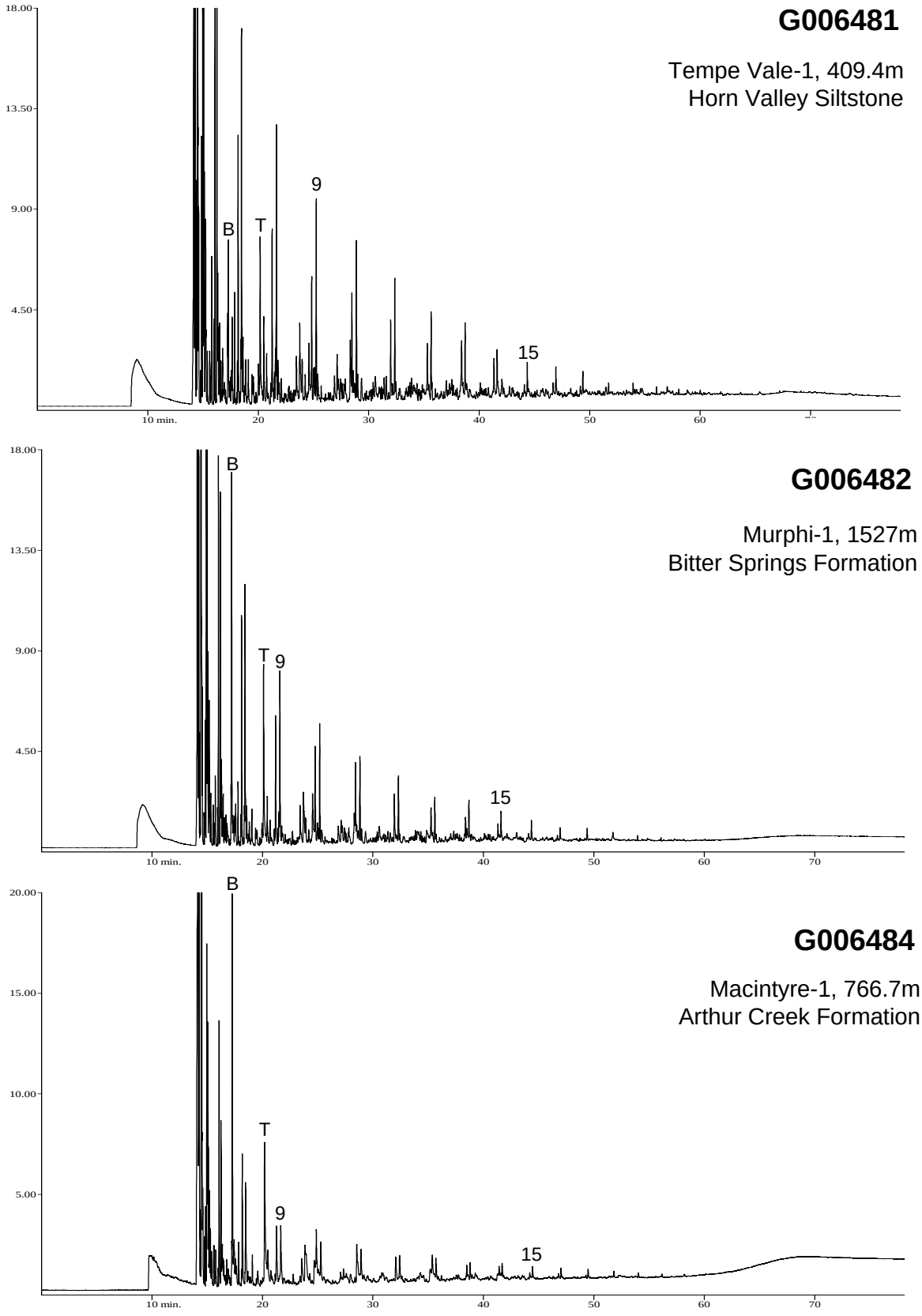


Figure 6b: Pyrolysis gas chromatograms of samples G006481 (top), G006482 (middle) and G006484 (bottom). Numbers refer to chain length of n-alkene/-ane doublets. B = benzene, T = toluene.

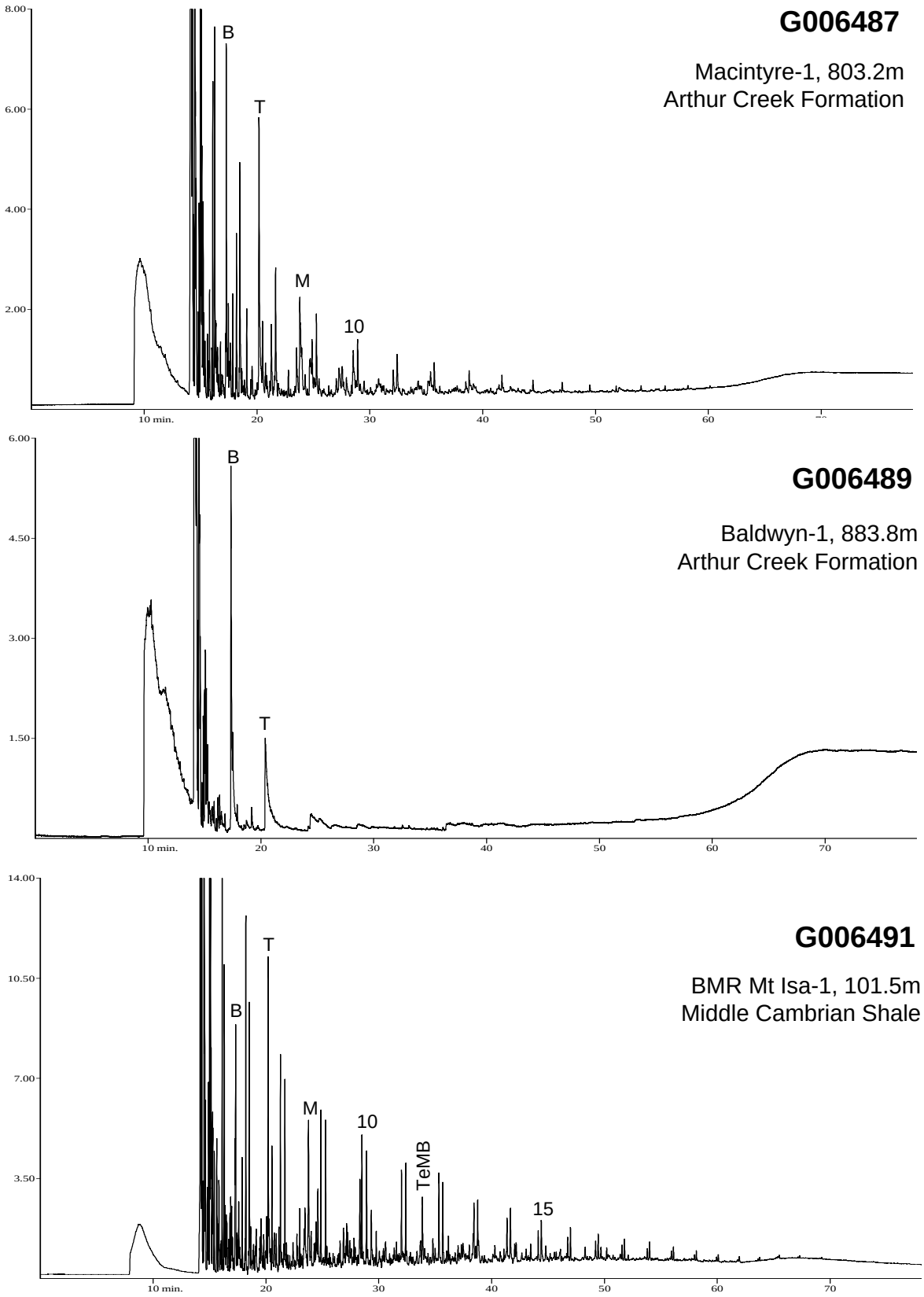


Figure 6c: Pyrolysis gas chromatograms of samples G006487 (top), G006489 (middle) and G006491 (bottom). Numbers refer to chain length of n-alkene/-ane doublets. B = benzene, T = toluene, M = meta- plus para-xylenes, TeMB = tetramethylbenzene.

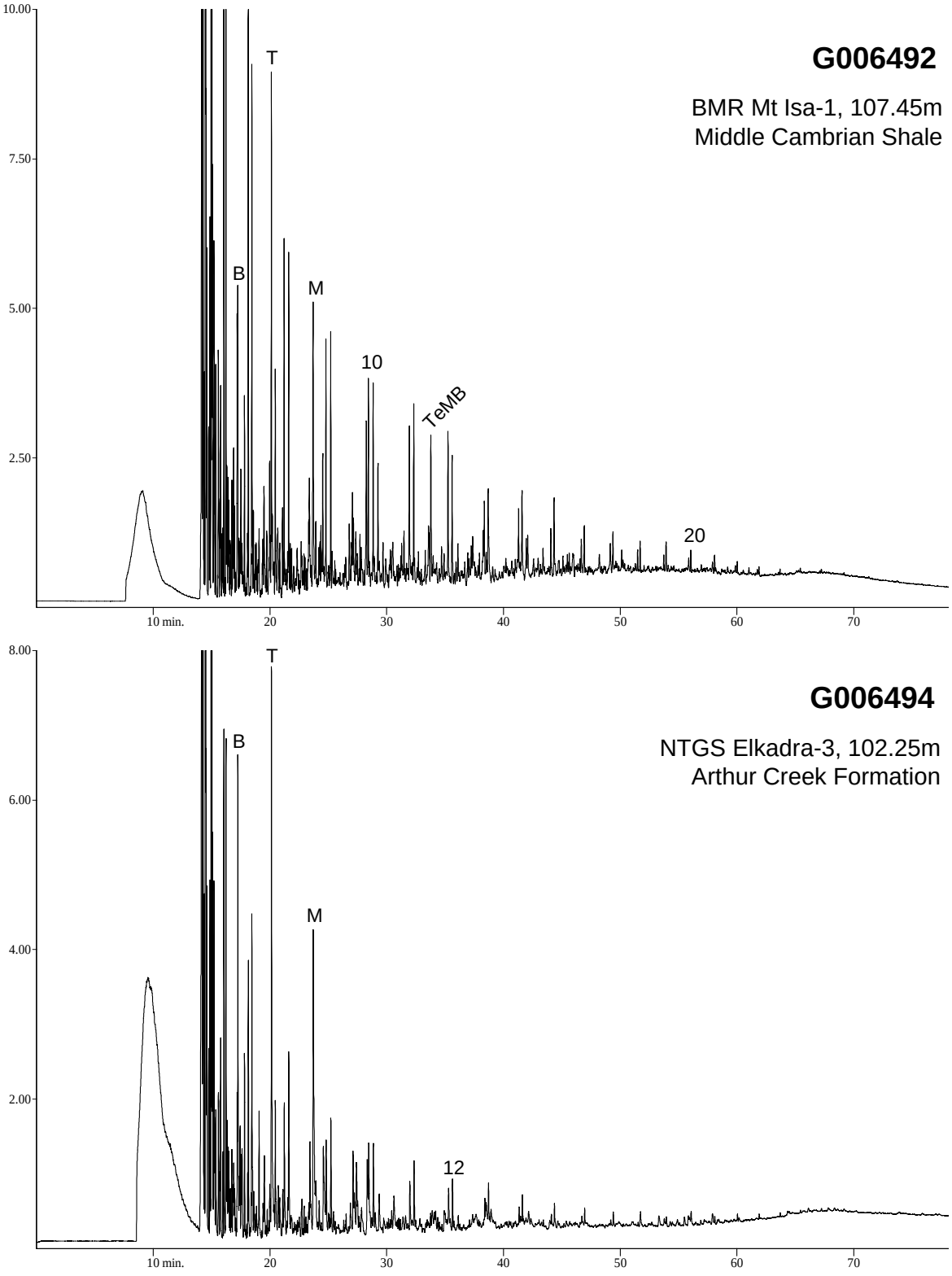


Figure 6d: Pyrolysis gas chromatograms of samples G006492 (top) and G006494 (bottom). Numbers refer to chain length of n-alkene/-ane doublets. B = benzene, T = toluene, M = meta- plus para-xylenes, TeMB = tetramethylbenzene.

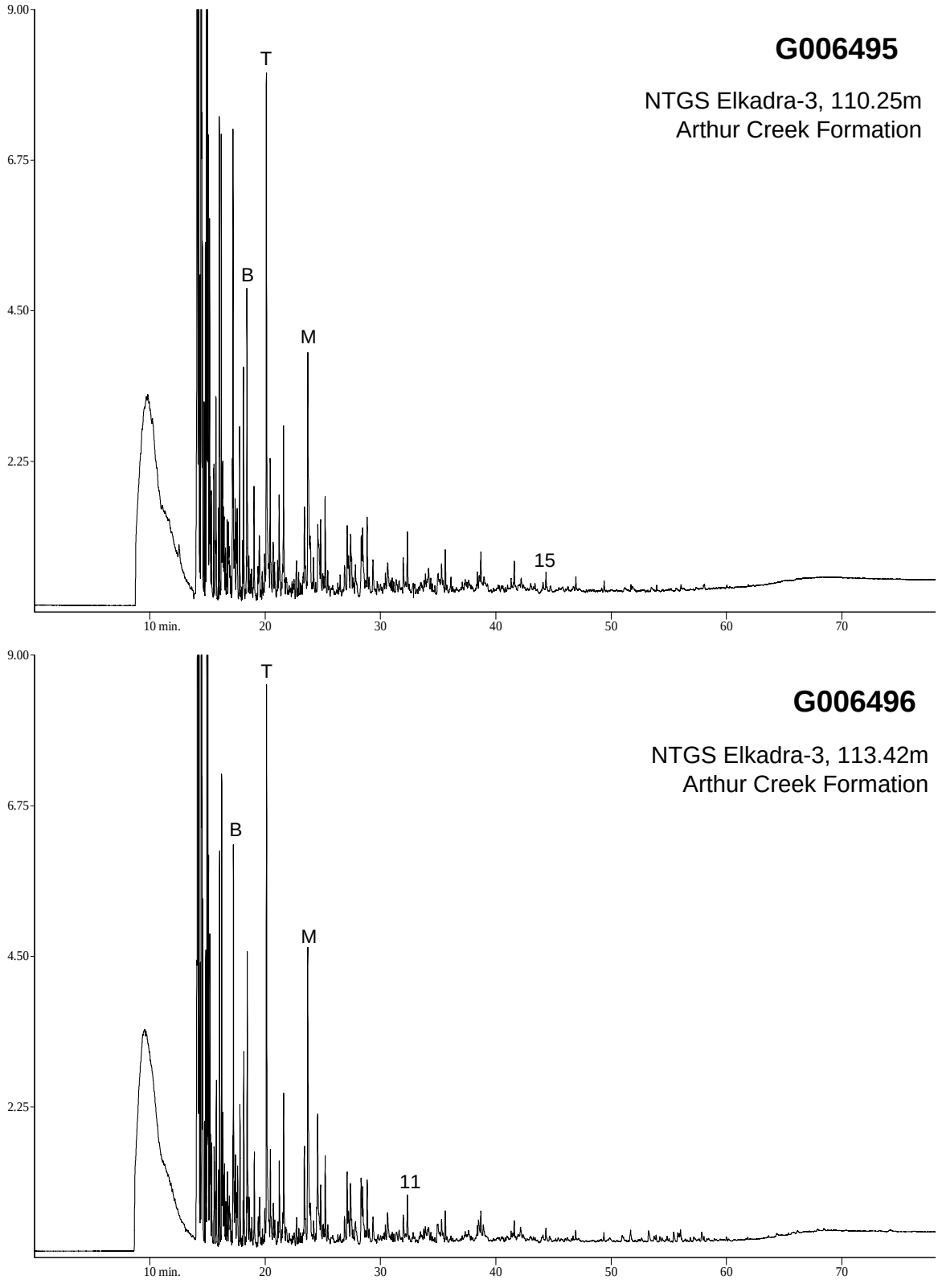


Figure 6e: Pyrolysis gas chromatograms of samples G006495 (top) and G006496 (bottom). Numbers refer to chain length of n-alkene/-ane doublets. B = benzene, T = toluene, M = meta- plus para-xylenes.

Table 4: PyGC boiling ranges

Sample	G006473	G006475	G006478	G006481	G006482	G006484	G006487	G006489	G006491	G006492	G006494	G006495	G006496
µg/g sample													
C1*1.1	6.0	5.2	3.8	638.0	439.8	81.8	504.2	408.5	2063.6	5292.2	1479.2	1067.2	1457.1
C2-C5 Total	8.8	8.7	8.8	1847.9	1335.0	215.9	729.1	328.0	6615.4	14626.6	1645.2	1413.6	1713.3
C6-14 Total (-Blank)	16.8	10.8	10.9	3211.3	1869.5	297.3	706.7	96.4	11428.2	23015.3	1590.8	1440.1	1553.7
C15_+ Total (-Blank)	0.0	0.0	0.0	1880.4	565.8	91.2	135.1	0.0	7885.1	19071.0	856.7	397.9	354.1
C1-5 Total	14.7	13.9	12.7	2485.9	1774.8	297.7	1233.3	736.5	8679.1	19918.8	3124.4	2480.8	3170.4
C1-30+ Total (-Blank)	31.5	24.7	23.5	7577.5	4210.1	686.3	2075.1	832.9	27992.3	62005.1	5571.8	4318.8	5078.2
GOR Total	0.88	1.28	1.17	0.49	0.73	0.77	1.47	7.64	0.45	0.47	1.28	1.35	1.66
C6-C14 Resolved	16.8	10.8	10.9	2643.8	1494.7	204.1	508.8	93.8	8625.1	17170.4	1256.8	1100.6	1211.1
C15+ Resolved	0.0	0.0	0.0	480.6	150.8	11.9	25.8	0.0	1198.5	2778.5	156.6	80.6	126.0
C1-30 Resolved	31.5	24.7	23.5	5610.3	3420.2	513.7	1767.8	830.3	18502.7	39867.7	4537.8	3662.0	4507.5
GOR Resolved	0.88	1.28	1.17	0.80	1.08	1.38	2.31	7.85	0.88	1.00	2.21	2.10	2.37
µg/g TOC													
C1*1.1	4582.4	3984.9	3203.7	18655.1	13917.2	6653.2	9442.1	3713.7	22828.0	33495.0	12862.6	11047.4	11943.4
C2-C5 Total	6735.6	6704.3	7362.7	54030.9	42246.9	17551.1	13653.1	2982.2	73179.7	92573.3	14305.8	14633.8	14043.5
C6-14 Total (-Blank)	12902.7	8335.9	9056.4	93896.4	59162.4	24172.8	13234.5	876.4	126417.9	145666.4	13832.8	14908.0	12735.2
C15_+ Total (-Blank)	0.0	0.0	0.0	54982.9	17905.9	7416.1	2529.6	0.0	87224.2	120702.6	7449.3	4118.9	2902.9
C1-5 Total	11318.0	10689.2	10566.5	72686.0	56164.0	24204.3	23095.1	6695.9	96007.7	126068.3	27168.4	25681.1	25986.9
C1-30+ Total (-Blank)	24220.7	19025.0	19622.9	221565.3	133232.4	55793.2	38859.3	7572.3	309649.8	392437.3	48450.5	44708.1	41625.0
GOR Total	0.88	1.28	1.17	0.49	0.73	0.77	1.47	7.64	0.45	0.47	1.28	1.35	1.66
C6-C14 Resolved	12902.7	8335.9	9056.4	77303.6	47299.2	16591.1	9527.5	852.6	95409.9	108673.5	10929.0	11393.4	9927.0
C15+ Resolved	0.0	0.0	0.0	14053.6	4771.0	966.6	482.3	0.0	13258.3	17585.3	1361.6	834.6	1032.9
C1-30 Resolved	24220.7	19025.0	19622.9	164043.3	108234.2	41762.1	33104.9	7548.5	204675.9	252327.1	39459.0	37909.2	36946.8
GOR Resolved	0.88	1.28	1.17	0.80	1.08	1.38	2.31	7.85	0.88	1.00	2.21	2.10	2.37

Table 5a: Normal aliphatic yields (µg/g TOC)

Sample	G006473	G006475	G006478	G006481	G006482	G006484	G006487	G006489	G006491	G006492	G006494	G006495	G006496
Aliphatics - Normals (µg/g TOC)													
C2:1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2:0	2552.1	2245.8	2933.3	17209.2	14633.3	6398.6	5834.0	1679.0	27135.2	35043.3	6256.7	6066.5	6173.8
nC3:1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
nC3:0	1531.1	1552.5	1890.9	14821.0	12032.4	5158.7	3952.0	839.5	20284.3	25506.6	3921.7	4167.0	3886.2
nC4:1	1065.0	1449.8	1634.1	4399.0	3964.9	1814.4	987.3	174.6	7724.7	9834.8	1188.2	1256.2	1073.3
nC4:0	554.2	460.9	705.5	5374.8	3990.4	1356.5	1019.8	134.3	5132.2	6323.5	886.2	1012.5	982.2
nC5:1	220.8	252.8	398.3	2278.1	1953.2	690.5	340.1	26.0	3412.2	3848.6	369.4	402.9	341.4
nC5:0	49.3	110.8	177.2	3375.5	2221.8	556.2	505.2	25.6	2972.9	4001.3	451.8	463.0	478.1
nC6:1	0.0	0.0	0.0	2496.5	1964.6	706.1	302.6	4.2	3716.9	4161.0	339.8	335.2	286.6
nC6:0	50.3	149.2	228.8	2983.7	1864.3	429.4	355.8	12.4	2116.9	2773.8	318.9	321.3	340.1
nC7:1	0.0	0.0	0.0	1854.5	1400.2	460.2	197.4	0.0	2652.2	2800.2	221.4	208.6	172.6
nC7:0	0.0	0.0	0.0	2744.7	1588.1	332.5	266.9	0.0	2152.5	2716.2	272.5	260.5	250.6
nC8:1	0.0	0.0	0.0	1461.7	998.9	255.0	110.1	0.0	1838.2	1930.5	136.4	113.9	94.7
nC8:0	0.0	0.0	0.0	2344.3	1286.7	303.3	200.7	0.0	1623.4	1869.7	187.4	186.5	176.7
nC9:1	0.0	0.0	0.0	1137.3	766.4	182.8	63.9	0.0	1400.7	1448.7	106.8	92.2	65.5
nC9:0	0.0	0.0	0.0	1691.7	923.4	194.5	132.5	0.0	1282.1	1400.7	127.5	118.6	106.5
nC10:1	0.0	0.0	0.0	956.6	650.1	175.1	99.2	0.0	1206.7	1223.8	113.6	64.9	64.2
nC10:0	0.0	0.0	0.0	1373.5	705.1	174.1	100.6	0.0	1113.6	1213.5	109.3	88.2	76.4
nC11:1	0.0	0.0	0.0	735.8	413.0	143.8	53.2	0.0	889.5	995.9	66.6	42.7	36.0
nC11:0	0.0	0.0	0.0	1081.5	578.7	127.2	82.8	0.0	940.1	1029.7	80.8	79.0	65.0
nC12:1	0.0	0.0	0.0	728.8	319.4	94.4	30.8	0.0	992.4	1047.9	57.3	33.6	23.4
nC12:0	0.0	0.0	0.0	793.1	380.7	100.6	50.8	0.0	810.9	821.9	55.8	51.4	41.5
nC13:1	0.0	0.0	0.0	674.6	182.7	65.9	15.3	0.0	660.2	587.3	28.6	21.9	15.8
nC13:0	0.0	0.0	0.0	672.4	321.2	76.8	47.8	0.0	641.3	598.1	44.2	46.8	30.7
nC14:1	0.0	0.0	0.0	434.9	138.0	35.0	6.3	0.0	496.5	535.4	23.2	13.0	10.7
nC14:0	0.0	0.0	0.0	483.8	223.7	53.6	24.7	0.0	633.3	786.4	32.5	32.9	22.5
nC15:1	0.0	0.0	0.0	121.3	67.3	28.1	5.9	0.0	354.5	339.0	13.3	11.1	7.7
nC15:0	0.0	0.0	0.0	319.5	182.5	55.6	21.0	0.0	540.8	600.8	23.9	20.9	18.5
nC16:1	0.0	0.0	0.0	142.7	53.7	22.7	4.1	0.0	235.9	276.0	9.7	5.6	5.4
nC16:0	0.0	0.0	0.0	324.1	111.6	45.3	17.8	0.0	386.6	394.3	16.7	14.9	10.7
nC17:1	0.0	0.0	0.0	148.3	18.3	13.6	2.7	0.0	248.7	234.8	7.0	5.8	2.8
nC17:0	0.0	0.0	0.0	266.0	113.7	40.6	11.4	0.0	301.0	316.0	15.0	13.8	10.2
nC18:1	0.0	0.0	0.0	107.4	9.7	6.0	0.0	0.0	181.4	166.3	5.3	1.6	2.2
nC18:0	0.0	0.0	0.0	124.8	46.1	26.3	9.2	0.0	249.6	216.6	21.6	7.8	18.0
nC19:1	0.0	0.0	0.0	35.3	5.0	0.0	0.0	0.0	133.4	128.4	7.9	0.0	3.1
nC19:0	0.0	0.0	0.0	126.2	44.6	20.8	8.7	0.0	218.4	243.5	10.0	7.5	9.6
nC20:1	0.0	0.0	0.0	21.6	6.6	0.0	0.0	0.0	120.4	120.9	14.0	0.0	0.0
nC20:0	0.0	0.0	0.0	86.6	26.1	13.3	7.7	0.0	153.5	155.3	16.1	8.6	19.5
nC21:1	0.0	0.0	0.0	20.1	3.9	0.0	0.0	0.0	78.7	113.2	0.0	0.0	0.0
nC21:0	0.0	0.0	0.0	66.8	12.3	8.9	7.1	0.0	109.8	140.6	8.0	7.0	6.6
nC22:1	0.0	0.0	0.0	4.7	4.9	0.0	0.0	0.0	64.3	73.1	0.0	0.0	1.8
nC22:0	0.0	0.0	0.0	48.4	11.4	5.1	4.1	0.0	89.1	102.3	8.0	3.1	5.7
nC23:1	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	30.8	56.2	0.0	0.0	0.0
nC23:0	0.0	0.0	0.0	19.7	5.1	0.0	1.2	0.0	76.6	78.9	5.9	2.6	3.0
nC24:1	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	25.0	24.3	0.0	0.0	0.0
nC24:0	0.0	0.0	0.0	26.0	0.0	0.0	0.0	0.0	47.8	48.4	4.5	1.4	2.3
nC25:1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.6	16.9	0.0	0.0	0.0
nC25:0	0.0	0.0	0.0	20.5	0.0	0.0	0.0	0.0	47.9	32.8	3.3	0.0	2.0
nC26:1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.7	21.0	0.0	0.0	0.0
nC26:0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	35.4	37.8	3.2	0.0	0.9
nC27:1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	13.2	0.0	0.0	0.0
nC27:0	0.0	0.0	0.0	15.3	0.0	0.0	0.0	0.0	23.9	19.4	2.4	0.0	0.0
nC28:1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2	7.2	0.0	0.0	0.0
nC28:0	0.0	0.0	0.0	14.5	0.0	0.0	0.0	0.0	14.2	16.3	0.0	0.0	0.0
nC29:1	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0	0.0
nC29:0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4	14.5	0.0	0.0	0.0
nC30:1	0.0	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
nC30:0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	4.9	0.0	0.0	0.0
nC31:1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
nC31:0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
nC32:1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
nC32:0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5b: PyGC individual compound yields- µg/g TOC (continued)

Sample	G006473	G006475	G006478	G006481	G006482	G006484	G006487	G006489	G006491	G006492	G006494	G006495	G006496
Aliphatics - Normals (µg/g TOC)													
Sum nC6-14	50.3	149.2	228.8	24649.5	14705.3	3910.4	2141.3	16.6	25167.4	27940.7	2322.7	2111.1	1879.6
Sum nC15+	0.0	0.0	0.0	2108.6	722.8	286.5	100.9	0.0	3861.3	4012.8	195.6	111.8	130.1
Aliphatics - Isoprenoids (µg/gTOC)													
iC18	0.0	0.0	0.0	106.4	0.0	0.0	0.0	0.0	209.9	188.6	4.1	0.0	0.0
Prist-1-ene	0.0	0.0	0.0	33.4	14.9	0.0	0.0	0.0	157.4	173.6	0.0	0.0	0.0
Prist-2-ene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.2	0.0	0.0	0.0
Aromatics (µg/g TOC)													
Benz	6715.3	4422.5	2823.6	1325.2	2388.0	1286.5	439.2	132.8	2064.5	1668.9	411.8	430.0	361.2
Tol	0.0	0.0	0.0	1585.6	1550.2	889.1	455.1	108.7	2835.3	2895.7	567.7	575.8	594.1
et-Benz	0.0	0.0	0.0	446.3	415.1	176.2	91.9	0.0	682.7	747.8	105.1	105.4	118.9
m+p Xyl	0.0	0.0	0.0	1161.2	784.0	446.6	301.8	31.0	1949.9	2299.4	464.5	416.7	534.7
Styr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
o-Xyl	0.0	0.0	0.0	584.3	526.4	165.9	59.0	0.0	854.8	925.3	113.5	95.2	172.4
Phenol	0.0	0.0	0.0	361.6	246.6	54.1	72.0	0.0	406.5	449.8	95.5	99.6	94.7
o-Cresol	0.0	0.0	0.0	93.3	43.4	15.7	10.4	0.0	264.8	255.7	18.9	14.7	9.8
m+p Cresol	0.0	0.0	0.0	531.6	281.3	30.3	16.0	0.0	537.3	511.5	71.3	63.6	58.6
Napht	0.0	0.0	0.0	227.0	185.0	104.4	30.2	0.0	341.4	320.8	22.4	15.6	33.7
2meNapht	0.0	0.0	0.0	186.1	120.0	23.5	10.6	0.0	351.5	468.5	34.5	22.9	46.7
1meNapht	0.0	0.0	0.0	186.8	75.9	18.0	11.7	0.0	173.2	217.1	17.0	16.5	22.3
Sum dimeNapht	0.0	0.0	0.0	780.0	211.1	25.3	19.7	0.0	770.6	1144.1	41.2	32.7	55.5
Tetra-meNapht	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum monoaromatic HC	6715.3	4422.5	2823.6	5102.6	5663.6	2964.2	1347.1	272.4	8387.2	8537.1	1662.5	1623.0	1781.3
Sum diaromatic HC	0.0	0.0	0.0	1379.8	592.0	171.2	72.1	0.0	1636.6	2150.5	115.1	87.7	158.1
Sum phenols	0.0	0.0	0.0	986.6	571.2	100.1	98.3	0.0	1208.6	1217.0	185.6	177.9	163.1
Sulphur Compounds (µg/g TOC)													
Thioph	0.0	0.0	0.0	542.9	279.3	91.8	54.2	0.0	1018.3	1435.7	84.7	87.4	76.4
2meThioph	0.0	0.0	0.0	102.5	77.3	0.0	41.6	0.0	571.2	612.3	38.2	39.9	63.4
3meThioph	0.0	0.0	0.0	726.3	324.8	0.0	99.5	0.0	1085.2	1419.3	120.8	132.3	95.0
2,5dimeThioph	0.0	0.0	0.0	23.0	0.0	0.0	0.0	0.0	365.9	422.5	6.0	7.4	0.0
2,3dimeThioph	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	252.2	308.8	0.0	0.0	0.0
Sum alkylthiophenes	0.0	0.0	0.0	851.8	402.0	0.0	141.1	0.0	2274.5	2762.9	165.0	179.6	158.4

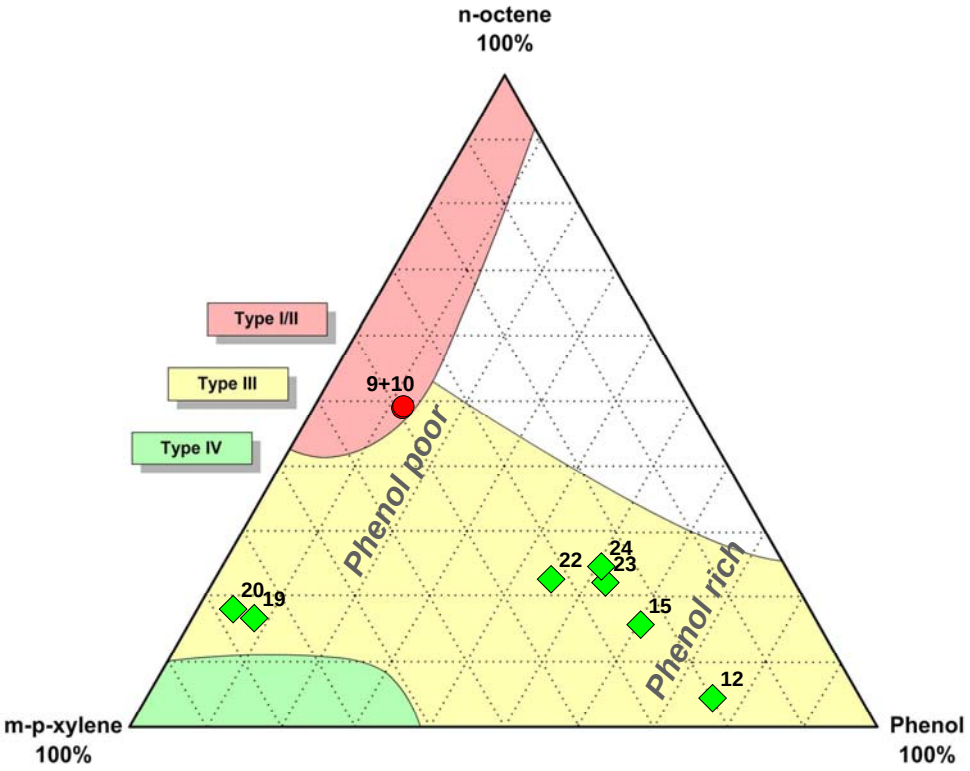


Figure 7: Kerogen type characterisation (after Larter 1984). Numbers refer to the GeoS4 short-labels (see Table 1)

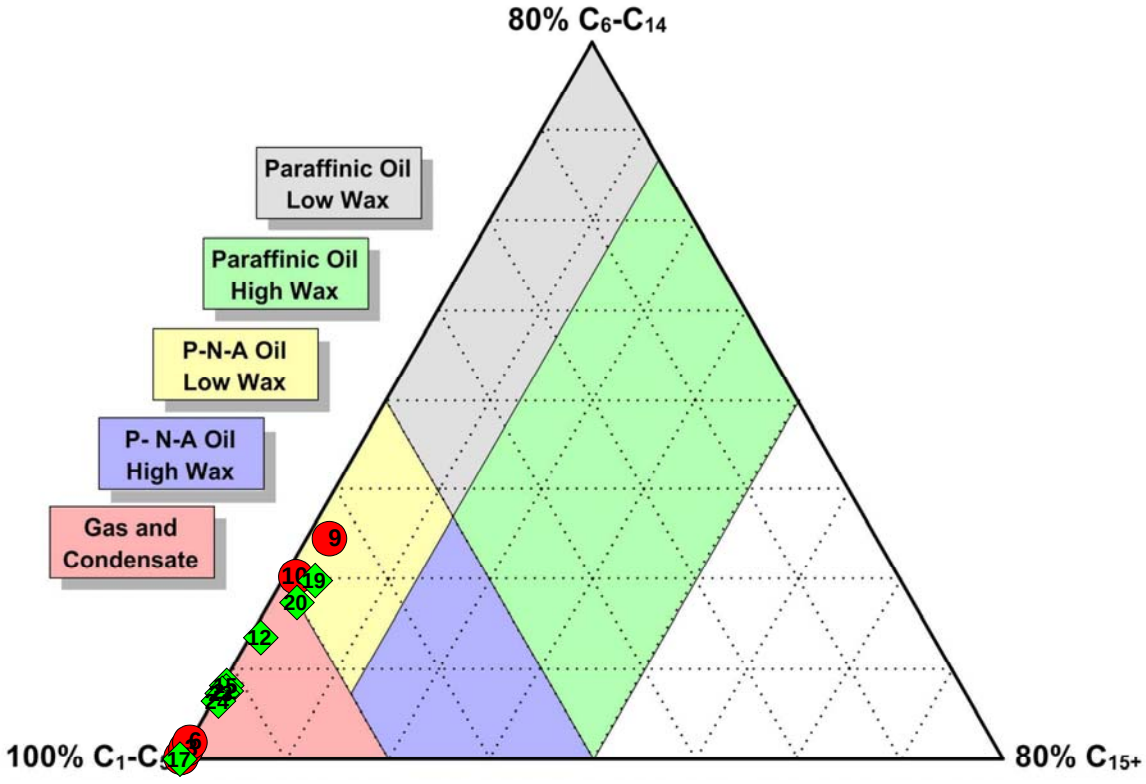


Figure 8: Petroleum Type Organofacies after Horsfield (1989). Numbers refer to the GeoS4 short-labels (see Table 1)

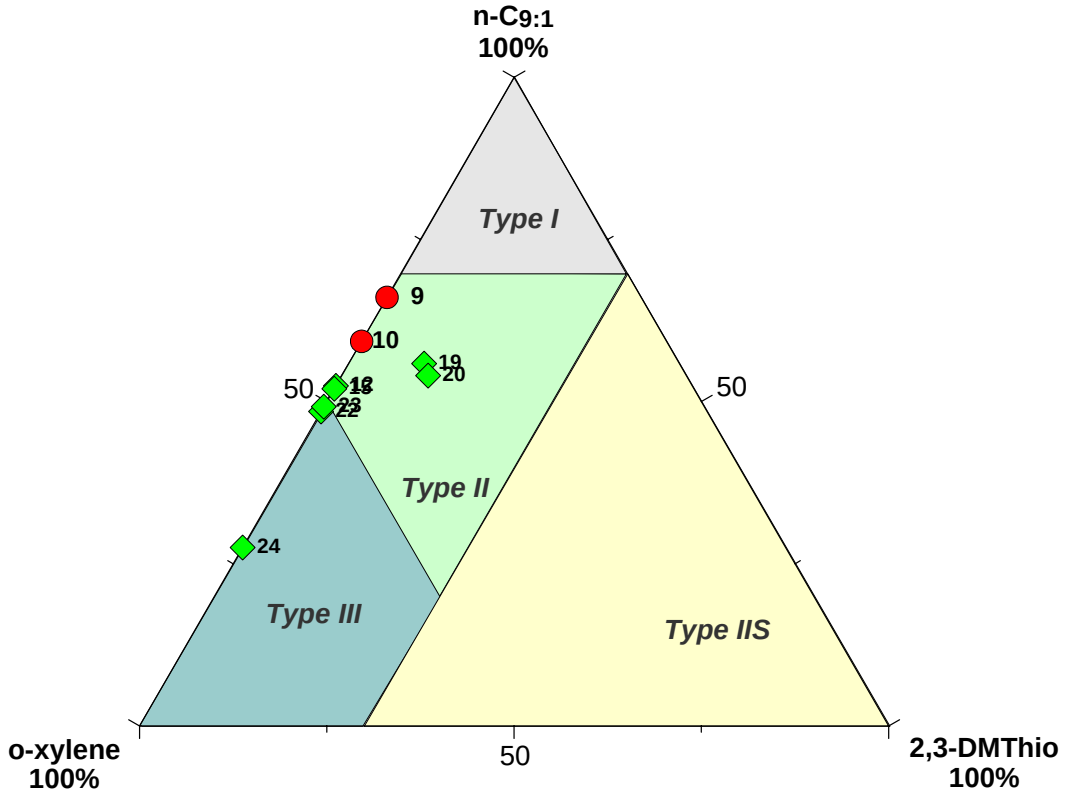


Figure 9: The kerogen type characterisation after Eglinton et al. (1990). Numbers refer to the GeoS4 short-labels (see Table 1)

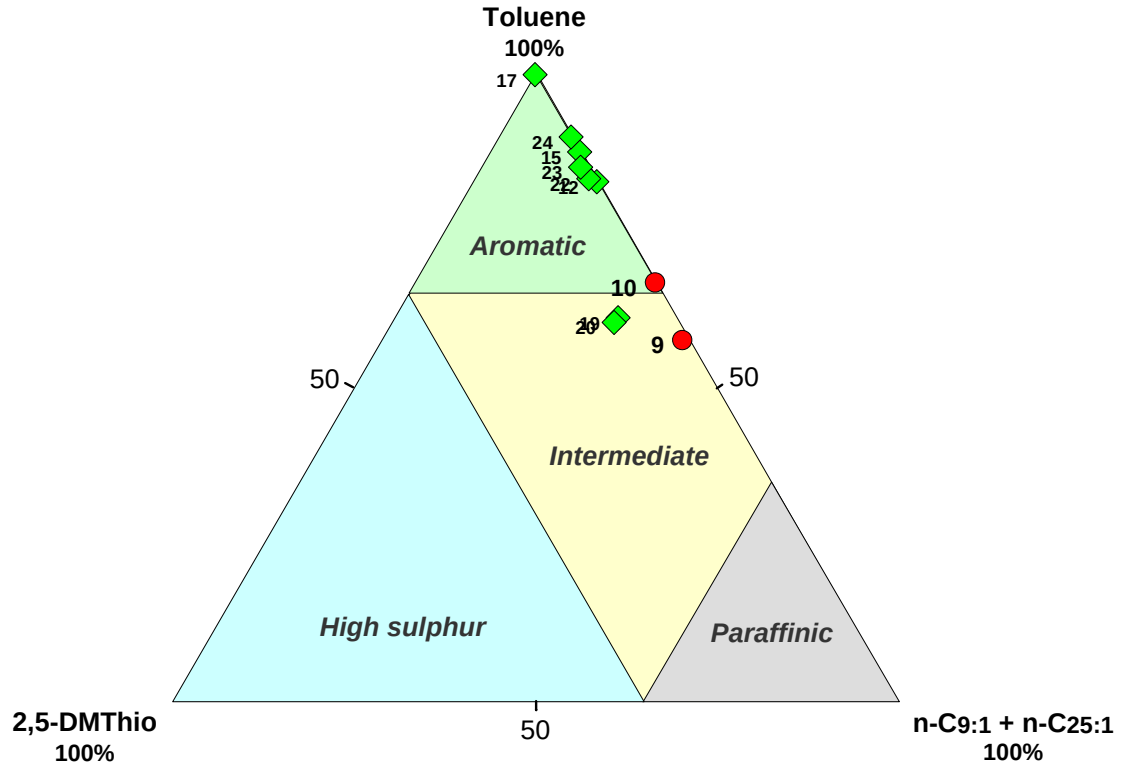


Figure 10: Differentiation of pyrolysate composition using relative proportions of selected alkyl-, aromatic-, and sulphur compounds after di Primio and Horsfield (1996). Numbers refer to the GeoS4 short-labels (see Table 1)

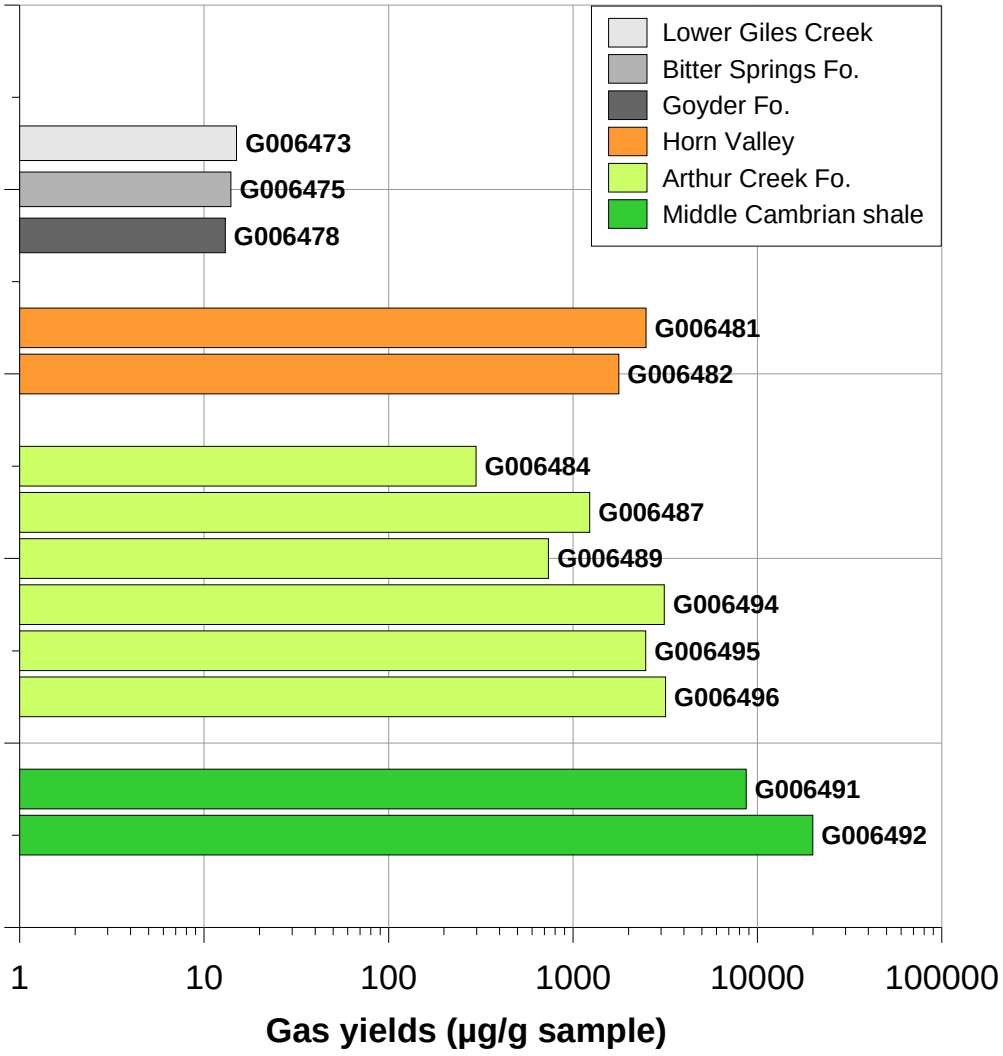


Figure 11: The remaining gas potential of samples from Amadeus and Georgina Basins