CHARACTERISTIC PROPERTIES OF THE ASPHALTIC SUBSTANCES IN SOUTHEASTERN TURKEY, THEIR DEGREES OF METAMORPHOSIS AND THEIR CLASSIFICATION PROBLEMS

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ABSTRACT. — The distinguishing characteristic properties of the asphaltic substances in Southeastern Turkey are studied in this work and their degrees of progress in metamorphosis are compared. The properties of these substances are also compared with the species of the asphaltic substances in the world and classification problems are discussed.

INTRODUCTION

The asphaltic substances in Southeastern Turkey indicate a great variety in character depending upon their localities, geological formation and the degrees of progress in metamorphosis. Before discussing these distinctive characteristics and the factors which had affected them, the author wishes to review the relationship existing between the conditional formation of the asphaltic substances and their characters generally.

It has been known that asphaltic substances were formed with the transformation of petroleum which is called metamorphosis. The influences such as time, temperature and pressure must have played a part in that transformation. The asphaltic substances having different characters were derived from petroleum depending upon the degrees of metamorphosis progressing in gradual stages.

The following table indicates the asphaltic substances having different characters depending upon the extent of metamorphosis of petroleum :

Petroleum

Non-asphaltic petroleum	Semi-asphaltic and asphaltic petroleum
↓	↓
Mineral waxes (Ozokerite)	Native asphalt
	↓
	Asphaltite
	↓
	Asphaltic pyrobitumen

Therefore, we may regard petroleum as passing in gradual stages first into the soft native asphalts, which in turn pass into harder native asphalts and then into asphaltites and finally into the asphaltic pyrobitumens which represent the final stage of metamorphosis.

The most important distinctive characteristics of these substances are given as follows :

Natural asphalts : These are substances having dark color, with variable hardness, comparatively non-volatile, composed principally of hydrocarbons containing very little or no oxygenated compounds and crystallizable paraffins, being fusible and largely soluble in carbon disulfide and yielding water-insoluble sulfonation products.

Asphaltites : These are dark-colored, comparatively hard and non-volatile solids. They are composed principally of hydrocarbons containing very little or no oxygenated compounds and crystallizable paraffins, they are difficultly fusible (fusion point is about 250-600°F), largely soluble in carbon disulfide and yielding water-insoluble sulfonation products.

Asphaltic pyrobitumens : These are dark-colored, comparatively hard and non-volatile solids. They are composed principally of hydrocarbons containing very little or no oxygenated compounds. They are infusible and largely insoluble in carbon disulfide.

According to Nellenstein, asphaltic bitumens contain three principal groups :

1. Medium (oily constituents).
2. Lyophile part or protective bodies (corresponding to asphaltic resins).
3. Lyophobe part (composed of colloidal particles of carbon).

Generally, protective bodies consist of highly unsaturated hydrocarbons which correspond to «asphaltic resins». An adsorption relation exists between components (2) and (3) forming a disperse phase and constituting «asphalt micelle» (corresponding to «asphaltenes»).

According to this hypothesis, the asphalt constituents may be classified into the following system :

Petrolenes (malthenes) and oily constituents : oily medium.

Asphaltous acids plus asphaltous acid anhydrides plus asphaltic resins : small amount of carbon with very large amount of protective bodies.

Asphaltenes : Carbon with considerable protective bodies.

Carbenes : Carbon with a small amount of protective bodies.

Carboids or pyrobitumens : Carbon with very little protective bodies.

Asphaltenes, resins and oily constituents are combined as a colloidal system, in which the asphaltenes are dispersed in the oily constituents and the solution is stabilized by the resin fraction which acts as a protective colloid.

Asphaltic bitumens are highly protected lyophobe sol in which each asphaltene micelle has a nucleus of carbon surrounded by layers of hydrocarbons. The properties of asphaltic substances depend upon the concentration of the dispersed phase, its degree of subdivision and the properties of the medium. The combination of these functions causes the formation of various substances from petroleum through the soft and viscous asphalts over to the asphaltites. In petroleum, asphalt micelles are present in slight amount in the oily medium forming a dispersed phase. The concentration of the oily medium diminishes and particle size of asphalt micelles correspondingly increases in evaporation during the metamorphosis of petroleum and the product represents the disperse system of soft to moderately hard asphalts. Several chemical processes such as oxidation, polymerization and condensation occur during metamorphosis and hydrocarbon molecules become rearranged into more complex molecules of higher molecular weight. Natural asphalts are evaporation products of petroleum. Asphaltites are the products of reaction and conversion rather than evaporation. Polymerization is considered as an essential factor in the formation of asphaltenes from oily constituents and resins by condensation of their molecules. The asphaltenes in turn polymerize to carbenes and these in turn are condensed to carboids. Petrolenes, asphaltenes and carbenes are soluble fractions of asphaltic bitumens in carbon disulfide, whereas carboids are insoluble.

Characteristic properties on the species of the asphaltic substances in the world are given in Table I.[1] As may be seen in Table I, asphaltites are characterized by their high fusing point (about 250-600° F), whereas natural asphalts soften about 60-325°F. Hardness on Mohs' scale is 1 or below for natural asphalts and it varies from 2 to 3 for asphaltites. The penetration of natural asphalts varies from 0 to 350; that value is about 0-5 for asphaltites.

The most important distinctive characteristics of asphaltites and asphaltic pyrobitumens are fusibility and solubility in carbon disulfide. Asphaltites are fusible and largely soluble in carbon disulfide (gilsonite 99-100 %, glance pitch 97-100 % and grahamite—on mineral matter free basis—90-100 %).

Asphaltic pyrobitumens which represent final stage of metamorphosis are not fusible. Their solubility in carbon disulfide is very small (wurtzilite 5-10 % albertite 2-10 % and impsonite trace to 6 %). Therefore, it is concluded that the solubility in carbon disulfide is related to the degrees of metamorphosis of the asphaltic substances passing gradual stages from asphaltite to asphaltic pyrobitumen. Carboid contents (non-mineral matter insoluble in carbon disulfide) of these substances increase as metamorphosis progresses.

THE OCCURRENCES OF THE ASPHALTIC SUBSTANCES IN SOUTHEASTERN TURKEY

The distinctive characteristic properties of the asphaltic substances in Southeastern Turkey are studied and the degrees of progress in metamorphosis of these occurrences are compared in this publication. The characteristic properties of these substances are also compared with the species of the asphaltic substances in the world and classification problems are discussed.

The discussion on the geological formations of these occurrences and their locations on the map are given in the publication titled «The Occurrences of the Asphaltic Substances in Southeastern Turkey and their Genesis» by R.F. Lebküchner, *M.T.4. Bull. no.* 72, 1969).

Asphaltic substances may occur either in a pure state or associated with varying amounts of mineral matter. The Qccurrences in Southeastern Turkey are generally associated with varying amounts of mineral matter in a finely divided form except Şikeftikan vein[2] (Mardin, Midyat, Kerburan) which occurs in filling fissures. According to the theory which is advanced by Clifford Richardson, mineral matter in a finely divided form, as for example colloidal clay, hastens the metamorphosis of petroleum by acting as a catalyser. It is highly probable that considerable amount of mineral matter associated with the asphaltic substances in Southeastern Turkey might have a catalytic effect on the metamorphosis of these occurrences.

Table II indicates water and mineral matter contents and the elemental compositions on the representative samples from Drilling 1 in Avgamasya[3] (Siirt, Şırnak) with an increasing range of depth.

Table II

Elementary composition of the samples from Drilling 1 in Avgamasya (Province of Siirt, Şırnak County)

Drilling I Depth (meters)	*Water, %*	*Mineral matter, %*	*C, %*	*H, %*	*S, %*[1]	*N, %*[2]	*C, % (water and mineral matter-free basis)*	*H, % (water and mineral matter-free basis)*
21.65- 37.45	0.18	34.81	53.25	4.48	6.51	0.75	81.91	6.89
76.75- 95.35	0.13	41.83	46.40	4.32	5.38	0.74	79.94	7.44
131.55-147.65	0.26	42.00	45.50	4.10	5.47	0.76	78.80	7.10
159.20-170.00	0.47	42.53	45.48	4.02	5.58	0.81	79.79	7.05

[1] ASTM, Bomb method.
[2] Kjeldahl method.

The average values of the water and mineral matter contents and the elemental compositions of the asphaltic substances occurring in Southeastern Turkey—including Milli vein (Siirt, Şırnak), Avgamasya Drilling No. 1 (Siirt, Şırnak), Harbol vein (Mardin, Silopi), Şikeftikan vein (Mardin, Midyat, Kerburan)—are also given in Table III. Carbon and hydrogen contents are calculated on mineral matter-free basis to eliminate the differences caused by various amounts of mineral matter and to obtain a basis for the comparison of elemental composition. Carbon content is corrected due to carbonate which mineral matter contains in varying amounts. Mineral matter also contains pyrite in various amounts.

Hydrogen content of asphaltic substances decreases slightly as metamorphosis extends. According to Table II, hydrogen content of these occurrences — on water and mineral matter basis — decreases with the following range of locations:

Table III

Elementary composition of the asphaltic substances from the various localities in Southeastern Turkey

	Water, %	*Mineral matter*, %	*C*, %	*H*, %	*S*, %[1]	*N*, %[2]	*C*, % (*water and mineral matter-free basis*)	*H*, % (*water and mineral matter-free basis*)
Şikeftikan vein[3] (Mardin, Midyat, Kerburan)	1.21	3.10	76.44	7.30	8.95	0.10	79.88	7.63
Harbol vein[3] (Mardin, Silopi)	0.96	25.85	59.31	5.55	7.47	0.76	81.04	7.59
Avgamasya, Drill 1[3] (Siirt, Şırnak)	0.26	40.29	47.82	4.23	5.73	0.76	80.44	7.11
Milli vein[3] (Siirt, Şırnak)	1.55	50.25	37.88	3.08	5.35	0.47	78.59	6.39

[1] ASTM, Bomb method.
[2] Kjeldahl method.
[3] R.F. Lebkuchner, M.T.A. *Bull.* no. 72, 1969.

Şikeftikan vein (Mardin, Midyat, Kerburan), Harbol vein (Mardin, Silopi), Avgamasya, Drilling 1 (Siirt, Şırnak), Milli vein (Siirt, Şırnak).

Oxygen content is considered the most reliable means of distinguishing between asphaltic pyrobitumens and non-asphaltic pyrobitumens (peat, lignite, bituminous coal). Bituminous substances originated from petroleum, such as natural asphalts, asphaltites and asphaltic pyrobitumens contain very small amounts of oxygenated compounds (up to 3 % of oxygen) — on mineral matter free basis — whereas non-asphaltic pyrobitumens (peat, lignite, bituminous coal, etc.) contain higher amounts of oxygen (about 3-44 %), varying with the degrees of progress in coalification.

Generally, oxygen content is calculated by difference. Since the samples contain considerable amounts of mineral matter, the correction was made due to change of the ash-forming constituents in weight on ignition. The oxygen content of the asphaltic substances on water and mineral matter free basis in the various locations of Southeastern Turkey, as calculated from the values in Tables II and III, vary from 0.1 % to 3.0 %. These values prove that these occurrences have petroleum origin.

The solubility values of these substances in carbon disulfide, negative diazo reaction and high sulfonation residues (Table IV and V) also prove petroleum origin of these substances.

The distinctive characteristic properties of the asphaltic substances from various locations in Southeastern Turkey are given in Table IV.

Fusibility is one of the characteristics which is considered in the classification of asphaltic substances. As may be seen in Table IV, the occurrences in Southeastern Turkey which are studied are not fusible. The effects of considerable amount of mineral matter, associated in a finely divided form, on the fusibility of these asphaltic substances must be also considered. The sample from Şikeftikan vein, which is in a pure state, is also infusible on account of 26.8 % carboid contents.

The amount of fixed carbon is also one of the useful characteristics differentiating asphaltites and asphaltic pyrobitumens. But considerable amount of carbonate in the mineral matter associated with the asphaltic substances in Southeastern Turkey interferes with the determination of fixed carbon due to carbon dioxide which is partly included volatile matter under the test conditions. Therefore, fixed carbon is not considered as a basis in the classification of these substances.

Consequently, the classification of these occurrences and the comparison in their degrees of progress in metamorphosis are based on the solubility values of these substances in carbon disulfide. Since the samples contain various amounts of mineral matter, their solubility values in carbon disulfide are calculated on water and mineral matter free basis and taken as a basis of comparison.

According to the values given in Table IV, the solubilities of the asphaltic substances in Southeastern Turkey in carbon disulfide (water and mineral matter free basis) decrease with the following range of locations: Şikeftikan vein: 68.9 %, Gercüş vein: 52.9 %, Harbol vein: 27.3 % to 43.2 %, Avgamasya Drilling 1 and 1A (21-170 m): 19.3 % to 24.5 %, Segürük vein: 19.8 %, Avgamasya Trench No. 7: 15.0 % to 16.8 %, Herbiş vein: 10.8 %, Milli vein: 10.1 %, Nivekara vein: 4.3 %, Kalük-Şivit vein: 1.1 %, Beşiri vein: 0.5 %, Ceffane-Tahtadizgehi Valley: trace to 0.4 %, Seridahli vein: trace, Gündükiremo vein: trace.

Figure 1 shows the solubility values in carbon disulfide (water and mineral matter free basis) comparatively on the occurrences from the various locations in Southeastern Turkey and the members of the asphaltic species in the world. Since the solubility values of these occurrences in carbon disulfide are related to the degrees of progress in metamorphosis, Figure 1 also shows the degrees of progress in the metamorphosis of these occurrences comparatively. As may bee seen in the figure, the degrees of progress in the metamorphosis of the occurrences in Southeastern Turkey increase with that range of locations: Şikeftikan vein, Gercüş vein, Harbol vein, Avgamasya, Drillings 1 and 1A (21-170 m), Segürük vein, Avgamasya Trench No. 7, Herbis. vein, Milli vein, Nivekara vein, Kalük-Şivit vein, Beşiri vein, Ceffane-Tahtadizgehi Valley, Seridahli vein Gündükiremo vein (the locations of these occurrences are given in Table IV).

The least metamorphosed occurrence is Şikeftikan vein as compared with all other occurrences. Kalük-Şivit vein, Beşiri vein, Ceffane-Tahtadizgehi Valley, Seridahli vein, Gündükiremo vein represent the final stage of metamorphosis.

Table V indicates the characteristics of the representative samples from Drilling 1 in Avgamasya (Siirt, Şırnak) with an increasing range of depth. Figure 2 shows the solubility values in carbon disulfide on the samples from Drilling 1.

Table IV

The most important characteristics of the asphaltic substances in southeastern Turkey [1]

Province	Mardin	Mardin	(IRAQ)	Mardin	Siirt	Siirt	Siirt	Siirt	Siirt	Siirt	Hakkâri	Mardin	Siirt	Siirt	Siirt
County, Region	Midyat Kerburan	Gercüş		Silopi	Şırnak	Şırnak	Şırnak	Şırnak	Şırnak	Şırnak	Uludere Gerür	Silopi	Şırnak	Şırnak	Şırnak
Village, location, vein	Şikeftikan vein	Gercüş vein	Kasrok vein	Hırbol vein	Avgamasya Drill. 1 and 1A (21-170 m)	Segürük vein	Avgamasya Trench no. 7	Herbiş vein	Milli vein	Nivekara vein	Kâlük-Şivit vein	Beşiri vein	Ceffane - Tahtadiz-gehi Valley	Seridahli vein	Gündükiremo vein
Table and figure no. related to the occurrences [2]	Tab. I, 17; Fig. 6	Tab. I, 5; Fig. 3	Tab. I & II, 3	Tab. I & II, 1; Fig. 1	Tab. I & III, 7; Tab. IV, pr. 8	Tab. I & III, 8; Tab. V	Tab. I & III, 7; Tab. IV, pr. 12/13	Tab. I, 10	Tab. I & III, 9.T ab; VI	Tab. I & III, 13; Fig. 5	Tab. I, 4; Fig. 2	Tab. I & II, 2	Tab. I & III, 19	Tab. I & III, 11; Fig. 5	Tab. I, 14
Color	Black	Dark grey to black	Dark brown to black	Black	Black	Dark grey	Black	Black	Black	Black	Dark brown	Black	Brown to black	Black	Black
Fracture	Conchoidal to hackly	Conchoidal	Conchoidal to hackly	Conchoidal	Conchoidal to hackly	Conchoidal to hackly	Conchoidal to hackly	Conchoidal to hackly	Conchoidal to hackly	Hackly	Conchoidal	Conchoidal to hackly	Hackly	Hackly	Conchoidal
Lustre	Bright	Dull	Slight bright	Slight bright	Slight bright to dull	Dull	Slight bright to dull	Slight bright to dull	Slight bright to dull	Slight bright	Dull	Dull	Slight bright to dull	Slight bright	Dull
Streak	Black	Dark brown	Black	Black	Black	Dark brown	Black	Dark brown to black	Black	Black	Dark brown to black	Black	Black	Black	Black
Hardness on Mohs'scale	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3
Penetration, at 77°F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fusing point, °F	Infusible	Infusible	Infusible	Infusible	Infusible	Infusible	Infusible	Infusible	Infusible	Infusible	Infusible	Infusible	Infusible	Infusible	Infusible
Water, %	1.2	0.2	0.6	0.5-1.4	0.1-0.5	0.9	0.8-1.1	0.6	1.5	1.3	2.1	2.6	2.1-7.3	5.0	3.8
Mineral matter, %	3.1	62.2	39.8	21.7-30.0	34.8-42.5	52.8	28.2-32.0	53.4	50.2	45.9	64.0	46.2	28.0-72.5	36.6	39.9
Solubility in CS_2, %	65.9	19.9	24.8	21.0-30.0	11.0-15.9	9.2	10.1-11.8	4.9	4.9	2.3	0.4	0.3	0-0.1	Tr.	Tr.
Solubility in CS_2, % (water and min. matter-free basis)	68.9	52.9	41.7	27.3-43.2	19.3-24.5	19.8	15.0-16.8	10.8	10.1	4.3	1.1	0.5	0-0.4	Tr.	Tr.
Non-mineral matter insoluble in CS_2, %	29.8	17.6	34.7	39.5-55.7	46.0-49.1	37.1	56.9-59.8	41.0	43.3	50.4	33.5	50.9	25.2-64.5	58.4	56.3
Non-mineral matter insoluble in CS_2, % (water and min. matter-free basis)	31.1	47.1	58.3	56.8-72.7	75.0-80.7	80.2	83.2-84.9	89.2	89.9	95.7	98.9	99.5	99.6-100.0	100.0	100.0
Solubility in petroleum naphtha (88°B), %	14.4	9.7	12.2	9.6-14.5	4.6-7.2	3.7	3.6	1.9	2.5	—	—	—	—	—	—
Carbenes, %	6.6	2.0	2.5	2.2-3.0	5.8-7.5	4.4	4.8	2.7	1.9	—	—	—	—	—	—
Sulfonation residue, %	96.7	95.8	96.4	95.3-96.4	95.4-97.3	96.1	96.4	97.4	97.1	—	—	—	—	—	—
Diazo reaction	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	—	—	—	—	—	—
Net heating value, Kcal./Kg.	7719	1211	5207	5812-6165	4438-5272	3884	4985-5360	3190	3554	4228	1862	3131	788-4140	4086	3531

[1] The test methods in this table are the same as in the publication «Asphalts and Allied Substances», H. Abraham.

[2] The tables and the figures are indicated in the publication *M.T.A. Bull.* no. 72, 1969, R.F. Lebküchner.

Table V[1]

Characteristic properties of the samples from Drilling 1 in Avgamasya (Siirt, Şırnak)[2]

Drilling I, depth (meters)[2]	21.65-37.45	76.75-95.35	131.55-147.65	159.20-170.00
Color in mass	Black	Black	Black	Black
Fracture	Conchoidal to hackly	Conchoidal to hackly	Conchoidal to hackly	Conchoidal to hackly
Lustre	Slight bright to dull	Slight bright to dull	Slight bright to dull	Slight bright to dull
Streak	Black	Black	Black	Black
Specific gravity	1.570	1.664	1.698	1.709
Hardness on Mohs' scale	2-3	2-3	2-3	2-3
Penetration, at 77° F	0	0	0	0
Fusing point, °F	Infusible	Infusible	Infusible	Infusible
Water, %	0.18	0.13	0.26	0.47
Mineral matter, %	34.81	41.83	42.00	42.53
Solubility in CS^2, %	15.92	12.65	11.80	11.27
Solubility in CS_2, % (water and min. matter-free basis)	24.49	21.80	20.44	19.77
Non-mineral matter insoluble in CS_2, %	49.09	45.39	45.94	45.73
Non-mineral matter insoluble in CS_2, % (water and min. matter-free basis)	75.51	78.20	79.56	80.23
Solubility in petroleum naphtha (88° B), %	7.22	5.46	4.97	4.60
Carbenes, %	7.57	5.99	5.83	6.13
Sulfonation residue, %	96.35	97.31	95.46	96.41
Diazo reaction	Negative	Negative	Negative	Negative
Net heating value Kcal/Kg	5272	4553	4438	4461

[1] The test methods in this table are the same as in the publication «Asphalts and Allied Substances» by H. Abraham.

[2] R. F. Lebküchner, *M.T.A. Bull.* no. 72, 1969.

According to the figure, the characteristics of these substances and their degrees of metamorphosis do not change significantly as the depth increases.

The samples from Drilling 1 in Avgamasya (Siirt, Şırnak) are distilled destructively in «Fischer» retort up to 530°C. The results of distillation are given in Table VI. As shown in the Table, the representative samples from Drilling 1 yield oil varying from 8.02 % to 11.96 %.

Table VI

The yield of the laboratory destructive distillation in Fischer retort on the samples from Drilling 1 in Avgamasya (Siirt, Şırnak)

Drilling 1, depth (meters)	21.65-37.45	76.75-95.35	131.55-147.65	159.20-170.00
Water (moisture + cryst. water), %	0.67	0.80	0.53	0.54
Gas, %	8.02	6.19	6.47	7.41
Distillate oil %	11.96	11.23	9.80	8.02
Distillation residue, %	79.35	81.78	83.20	84.03

A selective solvent fractionation is applied to determine the fractional constitution of asphaltic bitumens by using a series of solvent increasing surface tension. The fractions separated in different solvents do not represent definite hydrocarbons. They are arbitrary classes of material defined by the method of separation, surface tension and the miscibility properties of the solvents used.

The oily constituents and asphaltic resins together in the asphaltic bitumens constitute malthenes (petrolenes). These terms designate that portion of asphalt which is completely soluble in 88° Baume petroleum naphtha in which asphaltenes are precipitated. Different solvents (e.g. diethyl ether, hexane, isopentane, heptane and normal pentane) are used to separate petrolenes and asphaltenes in the asphaltic bitumens by various investigators.

The amount of petrolenes in the occurrences in Southeastern Turkey is indicated by solubility test in petroleum naphtha (88° Baume) (Tables II and IV). Carbenes and carboids (non-mineral matter insoluble in carbon disulfide) are also given in the same tables. According to these results, the fractional constitutions of the asphaltic substances from the various localities indicate a great variety. The asphaltic substances on the border between asphaltite and asphaltic pyrobitumen, e.g. the occurrences in Harbol, contain considerable amount of petrolenes (Table IV).

It is generally believed that petrolene content of the asphaltic substances decreases as the metamorphosis extends. Asphaltic pyrobitumens representing the last stage of metamorphosis (e.g. wurtzilite, albertite, impsonite) contain up to 2% of petrolenes (Table I). It is significant that the asphaltic substances among the occurrences in Southeastern Turkey containing large amounts of carboids and having the character close to asphaltic pyrobitumens still contain petrolenes to some

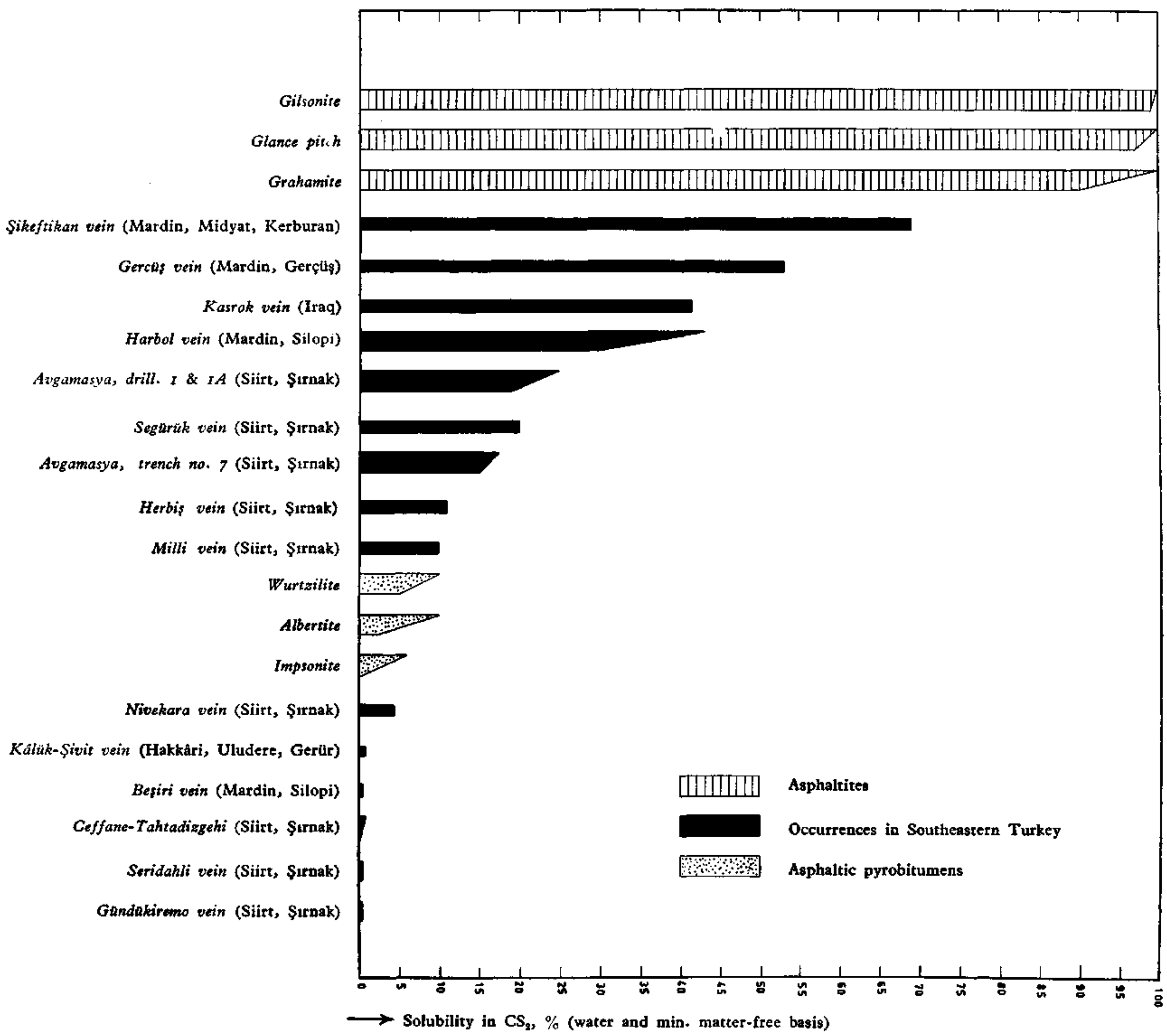

Fig. 1 - Comparison between the species of the asphaltic substances in the world and the degrees of metamorphosis of the occurrences in Southeastern Turkey.

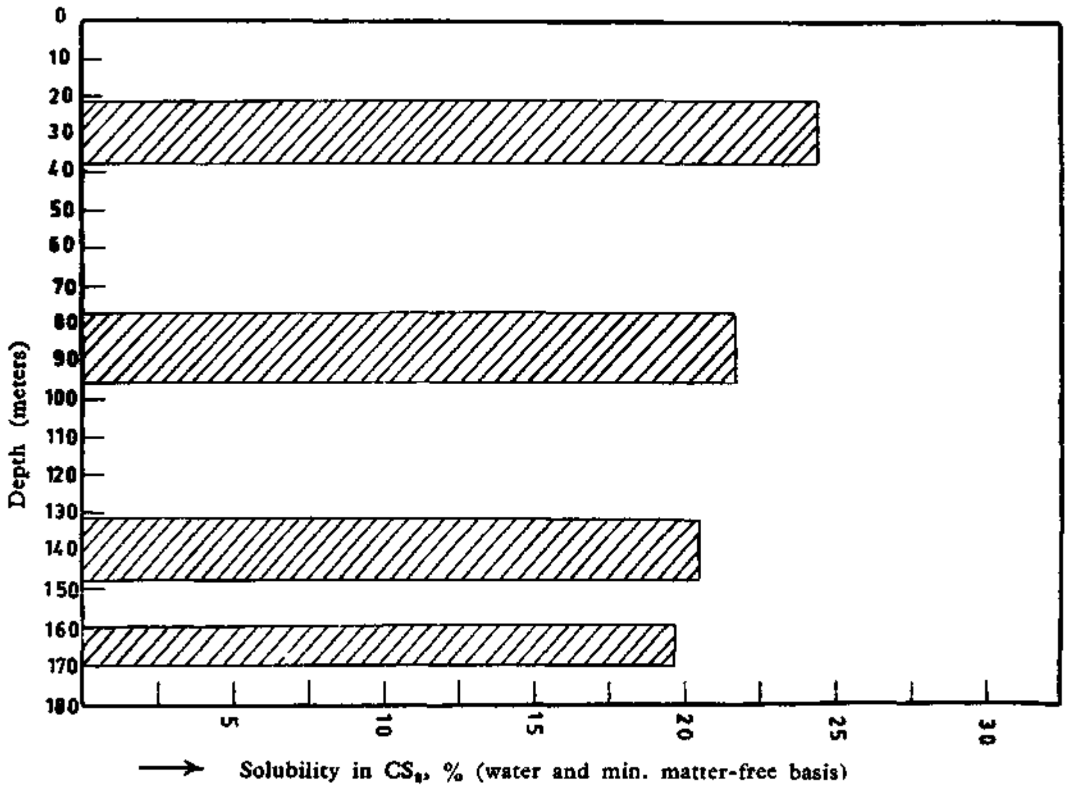

Fig. 2 - Solubility values in CS_2 v.s. depth of Drilling 1 in Avgamasya (Siirt, Şırnak).

degree (Table IV). They are composed of all types of constituents from the lightest petrolene to the products of the final stage of metamorphosis. Therefore, it is concluded that the mechanism of the chemical reactions during metamorphosis and the nature of the constituents have a great variety depending on the metamorphism, such as pressure, catalyst and heat.

THE CLASSIFICATION PROBLEMS OF THE OCCURRENCES IN SOUTHEASTERN TURKEY

Which place should the asphaltic substances in Southeastern Turkey occupy in the classification system in Table I indicating the characteristics of the asphaltic species in the world ?

As explained before, the comparison in the degrees of progress in the metamorphosis of these substances was based on the solubility values in carbon disulfide (water and mineral matter basis). The classification of the occurrences in Southeastern Turkey is also based on the same property.

The solubility values in carbon disulfide (water and mineral matter free basis) in the occurrences in Southeastern Turkey and the asphaltic substances in the world are comparatively shown in Figure 1. According to H. Abraham, wurtzilite, albertite and impsonite having solubility values in carbon disulfide not more

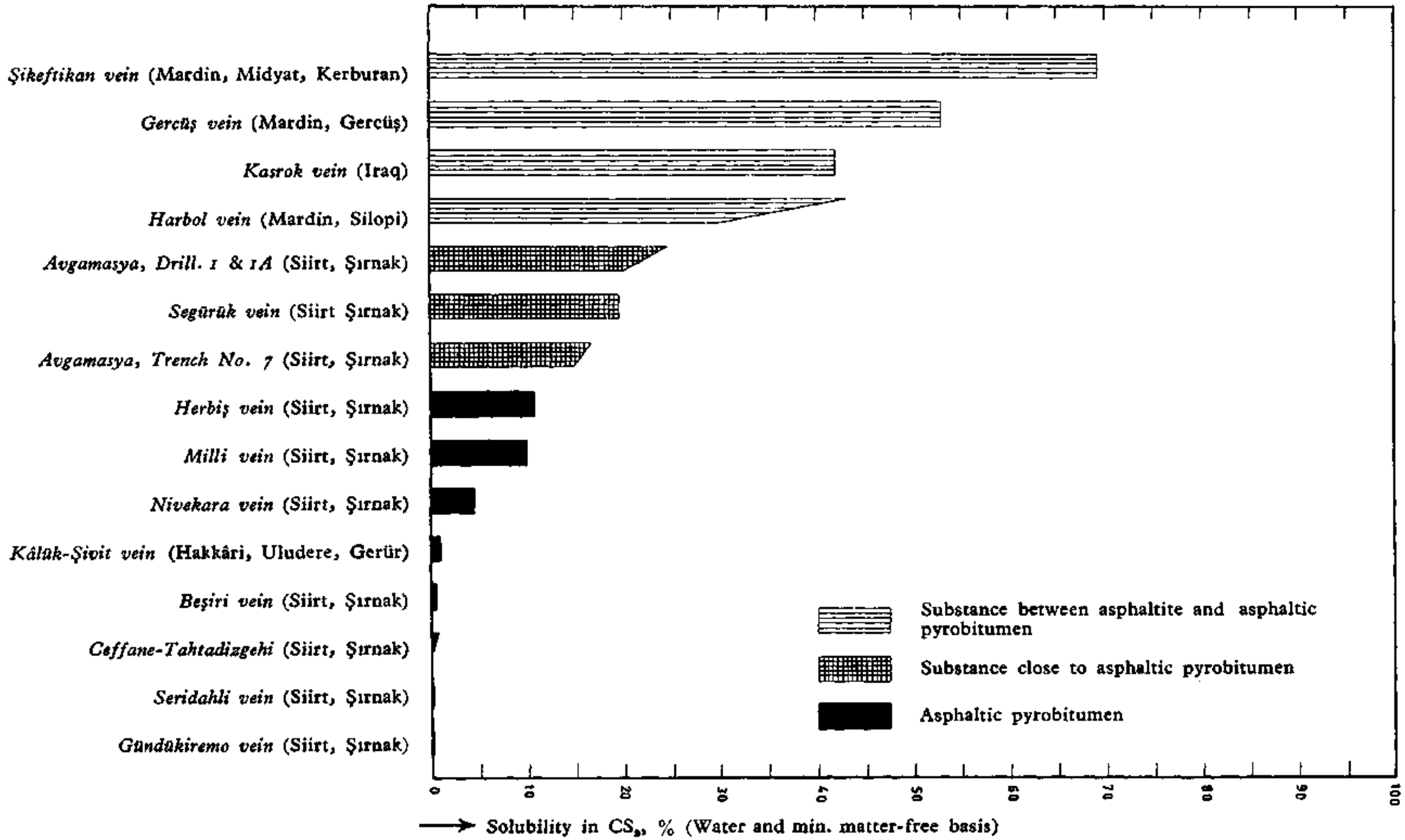

Fig. 3 - Classification of the occurrences in Southeastern Turkey according to the basis in Table VII.

than 10%, are classified as asphaltic pyrobitumens (Table I). Gilsonite, glance pitch and grahamite having solubility in carbon disulfide (water and mineral matter free basis) in the values of 99-100%, 97-100 % and 90-100 %, respectively, are included in the species of asphaltites.

As may be seen in Figure 1, some occurrences in Southeastern Turkey are included in asphaltic pyrobitumens; some of them are near to the characteristics of asphaltic pyrobitumens, but metamorphosis of these substances has not progressed as far as in asphaltic pyrobitumens. Some other substances have characteristics on the border between asphaltite and asphaltic pyrobitumens.

The author proposes the classification indicated in Table VII for the occurrences in Southeastern Turkey having a great variety in their character as the locations vary.

Table VII

Solubility in carbon disulfide (water and mineral matter free basis)	*Species*
up to 15 %	Asphaltic pyrobitumen
15 % to 25 %	Substance close to asphaltic pyrobitumen in character
25 % to 90 %	Substance between asphaltite and asphaltic pyrobitumen

According to the basis in Table VII, the classification determining the species of the occurrences in Southeastern Turkey which are having characteristics in Table IV is given in Table VIII.

The occurrences from Ceffane-Tahtadizgehi Valley having the character of shale are classified as asphaltic pyrobituminous shale in Table VIII. The veins of Gündükiremo (Siirt, Şırnak), Seridahli (Siirt, Şırnak), Beşiri (Mardin, Silopi), Kalük-Şivit (Hakkari, Uludere, Gerür), Nivekara (Siirt, Şırnak), Milli (Siirt, Şırnak), Herbiş (Siirt, Şırnak) are classified as asphaltic pyrobitumens (associated with mineral matter), Avgamasya-Drilling 1 and 1A, Trench no. 7 (Siirt, Şırnak) and Segürük vein (Siirt, Şırnak) as the substances near to asphaltic pyrobitumen in character (associated with mineral matter), the veins of Harbol (Mardin, Silopi), Kasrok (Iraq), Gercüş (Mardin, Gercüş) as the substances between asphaltite and asphaltic pyrobitumen (associated with mineral matter) and Şikeftikan vein (Mardin, Midyat, Kerburan) as the substance between asphaltite and asphaltic pyrobitumen (in pure state) (Table VIII).

Figure 3 shows the classification of the occurrences in Southeastern Turkey according to the basis in Table VII.

The substances having the characters between asphaltite and asphaltic pyrobitumen, like the occurrences in Southeastern Turkey, also occur in the provinces of Mendoza and Neuquen in Argentina.

Table VIII

Classification of the asphaltic substances in Southeastern Turkey

Occurrences in Southeastern Turkey	*Table and figure no.*[1] *related to the occurrences*	*Species of asphaltic substances*
Ceffane-Tahtadizgehi Valley (Siirt, Şırnak)	Table I & III, 19	Asphaltic pyrobituminous shale
Gündükiremo vein (Siirt, Şırnak)	Table I, 14	Asphaltic pyrobitumen (associated with mineral matter)
Seridahli vein (Siirt, Şırnak)	Table I & III, 11; Fig. 5	
Beşiri vein (Mardin, Silopi)	Table I & II, 2	
Kâlük-Şivit vein (Hakkâri, Uludere, Gerür)	Table I, 4; Fig. 2	
Nivekara vein (Siirt, Şırnak)	Table I & III, 13; Fig. 5	
Milli vein (Siirt, Şırnak)	Table I & III, 9; Table VI	
Herbiş vein (Siirt, Şırnak)	Table I, 10	
Avgamasya, Trench No. 7 (Siirt, Şırnak)	Table I & III, 7; Table IV, pr. 12/13	Substance close to asphaltic pyrobitumen in character (associated with mineral matter)
Segürük vein (Siirt, Şırnak)	Table I & III, 8; Table V	
Avgamasya, Drilling 1 & 1 A (21-170 m) (Siirt, Şırnak)	Table I & III, 7; Table IV, pr. 8	
Harbol vein (Mardin, Silopi)	Table I & II, 1; Fig. 1	Substance between asphaltite and asphaltic pyrobitumen (associated with mineral matter)
Kasrok vein (Irak)	Table I & II, 3	
Gercüş vein (Mardin, Gercüş)	Table I, 5; Fig. 3	
Şikeftikan vein (Mardin, Midyat, Kerburan)	Table I, 17; Fig. 6	Substance between asphaltite and asphaltic pyrobitumen (in pure state)

[1] The tables and figures are indicated in the publication: Lebküchner, R. F., *M.T.A. Publ.*, no. 72, 1969.

As may be seen in Table VIII, the classification given in the publication of H. Abraham, titled «Asphalts and Allied Substances» is not sufficient to classify and to define the occurrences having the characters on the border between asphaltite and asphaltic pyrobitumen.

Is it required to add more details to the present classification to define and classify the species of the occurrences representing gradual stages of metamorphosis like the occurrences in Southeastern Turkey?

The occurrence in Harbol (Mardin, Silopi) was named as «harbolite» by Cunningham-Craig. It may be a subject of discussion also whether these substances should be named originally as member.

The author does not recommend to give an original name to each substance as member, since these substances have a gradual variation in character from place to place where they occur and there is no sharp line of demarcation between the various types.

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