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Palynofacies and Environment of Deposition of HA-001 Well, Shallow offshore Western Niger Delta Basin, Nigeria.

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Abstract

Palynofacies analysis of sedimentary intervals in HA-001 well was carried out on seventy-five (75) ditch cutting samples collected from western Niger Delta, Nigeria with the aim of establishing the palynofacies and environment of deposition interpretations of the studied sections. Palynofacies analysis showed the dominance of land phytoclast, amorphous matter and miospores over marine palynomorphs. Palynomacerals I and II were abundant while Palynomacerals III and IV gave few occurrences. The paleoenvironmental interpretation of the studied well intervals using the ternary plot diagram of kerogen indicated deposition in distal dysoxic-anoxic shelf. This plot showed that HA-001 well is prone to optimum petroleum generation.

Keywords: Dysoxic-anoxic; Palynofacies; Palynomacerals; Palynomorphs; Phytoclast

1.0 Introduction

The concept of palynofacies was first described as the quantitative and qualitative palynological study of the total particulate organic matter assemblage. Palynofacies analysis involves the identification of individual palynomorph, plant debris and amorphous components, their absolute and relative proportions, size spectra and preservation states (Combaz 1964, 1980). However, some authors used terms such as organic matter (Lorente, 1990) palynodebris (Van Der Zwan, 1990; Traverse, 2009) and kerogen (Tyson, 1995). Durand (1980) and Brooks (1981), highlighted various definitions of this term. It is used to explain the dispersed particulate organic matter of sedimentary deposits that is not soluble in hydrochloric (HCl) and hydrofluoric acids (HF). Palynomorphs, phytoclasts and amorphous organic matter are the three main groups of morphological constituents that can be recognized within kerogen assemblages. Palynomorph refers to all HCl and HF resistant organic-walled microfossils. Phytoclast was introduced by Bostick (1991) to explain all dispersed clay to fine sand-sized particles of plant derived Kerogen.

(Jansonius and McGregor, 1996). Some of the uses of palynofacies include; identification of regressive-transgressive trends in stratigraphic sequence, characterization of the depositional environments, deriving correlations at levels below biostratigraphic resolution and producing detailed organic facies models. Palynofacies assemblage plot of the amorphous organic matter-phytoclast- palynomorphs has been used to describe the paleoenvironments (Tyson, 1995). The information about the redox status of the environment that are necessary for the preservation of amorphous organic matter can be deduced. Atta-Peters *et al.* (2015) carried out palynofacies and source rock potential analyses on samples from ST-7H well, offshore Tano basin. Five palynofacies associations were identified using relative abundances of palynomacerals. The oxygenation conditions of the depositional environments were determined subsequently. Aptian to Maastrichtian age have been confirmed using index palynomorphs. Lucas and Ebahili (2017) studied the palynofacies of sedimentary intervals of Ogbabu-1 well in Anambra basin using sedimentologic and palynological criteria. Shelfal and shallow marine environment of deposition were delineated for the studied intervals while the major lithologies encountered were sand and shale. The aim of the study is carry out palynofacies analysis and to infer the paleoenvironment of deposition of the studied well.

3.0 Materials and Methods

3.1 Location of Study Area and Geology of Niger Delta

HA-001 well lies within latitudes 4º 09' 10.9" N and longitudes 6º 14' 1.8" E in the shallow offshore area, western Niger Delta, Nigeria. The name of the well has been coded by Shell Production and Development Company, Nigeria due to proprietary reasons. The location of the wells is shown in Figure 1.

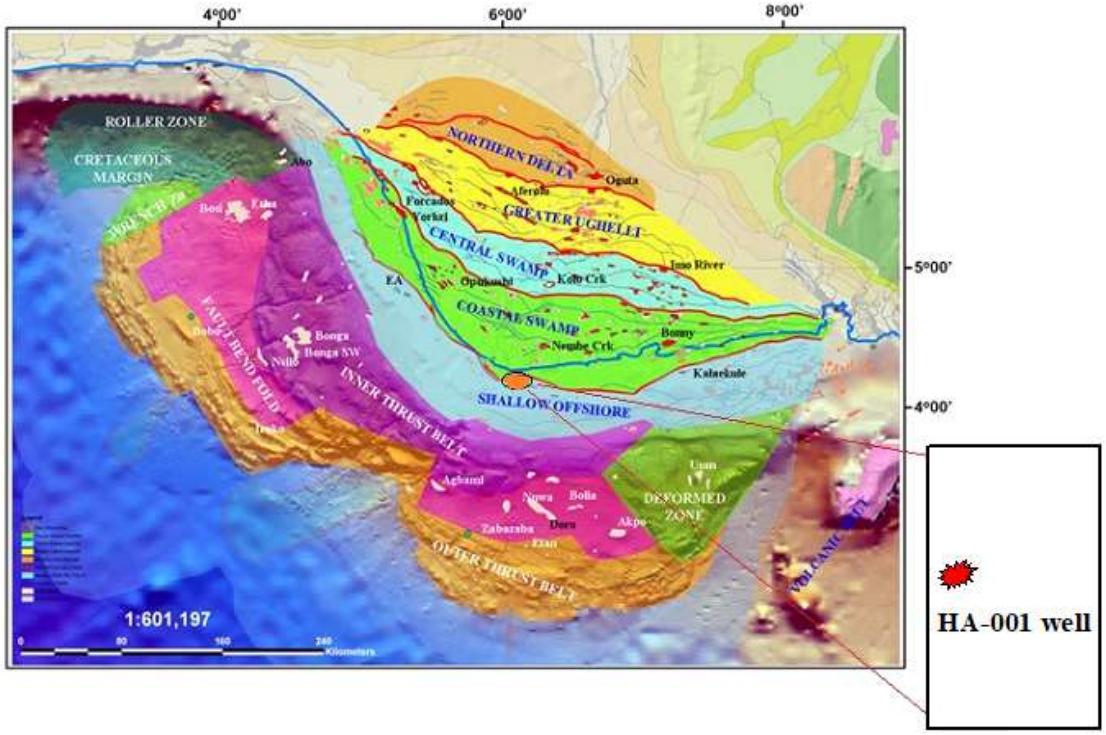

Figure 1: Location Map of the Study Area within the Shallow offshore Depobelt of the Niger Delta (modified after Doust and Omatsola, 1990)

Five major depobelts are documented in the Niger depobelt with each having its own sedimentation, deformation, and petroleum production history. The oldest is the northern delta province, superimposed comparatively shallow cellar. This depobelt has the growth faults that are described as the oldest, in general revolving with increase in seaward steepness. The second is the Greater Ughelli Depobelt. The third, the central delta province swamp depobelt has well-articulated structures such as deeper rollover crest that shift seaward for any growth faults. It has two parts: Central Swamp Depobelts I and II, which are well thought-out by some authors as distinct and separate depobelts. The fourth depobelt, which is the the Coastal Swamp Depobelt, is located in the far-away delta province. This is the most structurally multifaceted onshore depobelt owing to internal gravity tectonics on the modern continental slope. It also has two parts: Coastal Swamp Depobelts I and II also considered by some workers as separate entities. The fifth depobelt is the Offshore Depobelt. Again, this can be separated into Shallow Offshore and Deep Offshore Depobelts.

3.2 Methods

Palynofacies administration was undertaken on seventy-five ditch cutting samples through different processes which involved digestion of the sample with HCl and HF acids. This was followed by sieving with 5 and 10 µm mesh sieves. Subsequently, oxidation, mounting and analysis of the prepared slides followed under the binocular microscope with the aim of observation and notification of palynomorphs and palynofacies. The laboratory analysis of the samples provided by Shell Production and Development Company was carried out at Crystal Age Limited, Lagos, Nigeria. Palynofacies assemblage plot of the amorphous organic matter-phytoclast- palynomorphs has been used to describe the paleoenvironments (Tyson, 1995). The information about the redox status of the environment that are necessary for the preservation of amorphous organic matter can be deduced.

4.0 Results and Discussions

4.1 Palynomacerals

The well generated few to abundant amount of organic matter. There is good recovery of palynomaceral I, II, III and IV from the studied wells. (Figure 2)

4.1.1 Palynomaceral I (PMI)

The observed palynodebris I from the wells are mainly amorphous organic matter are structureless, light-brown to brown in colour, strong yellow-orange fluorescence particles and irregular in shape particulate organic matter. Batten and Stead (2005) described palynomaceral I as flora debris of variable sizes and humic gel-like substances.

4.1.2 Palynomaceral II (PM II)

These are observed from the wells as amber-coloured fragments with moderate orange fluorescence sizes are from 20-40um. Tyson (1995) described PMII as a product of higher plants formed from either cell or cavity filling secretions. Both PMI and PMII are mainly composed of Amorphous Organic Matter (AOM).

4.1.3 Palyonaceral III (PM III)

These are generally referred to as translucent phytoclasts. They are subdivided into wood remains, degraded plant cuticle and cuticle remains with biostructures (Tyson, 1995). PM III remains are formed from leaves. Recovered PMIII from the wells are light to dark brown in colour with cellular structures.

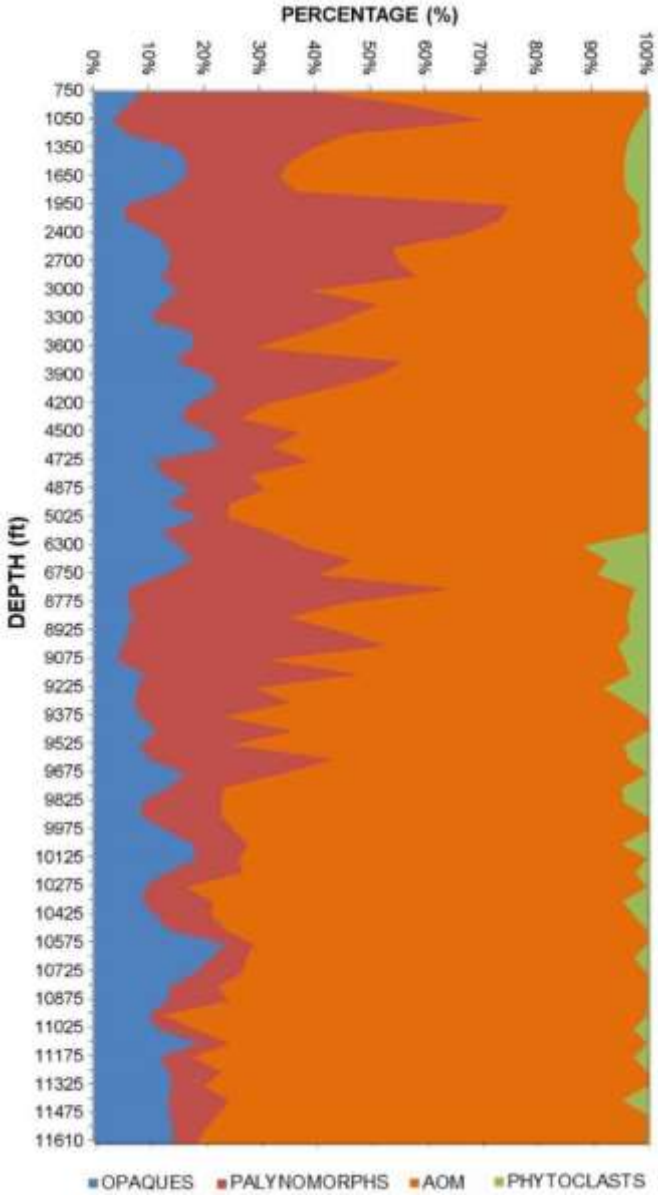

Figure 2: Frequency distribution of palynofacies in well HA-001

4.1.4 Palynomaceral IV (PM IV)

Observed PM IV from the wells are dark in colour with sharp angular outlines without fluorescence. These are known as oxidized wood or opaque phytoclasts (Tyson 1995). They can be equidimensional and blade-shaped in terms of their length/width ratio.

4.2 Distribution of Palynomacerals in HA-001 Well

The characterization and description of palynofacies under transmitted light microscope was carried out qualitatively and qualitatively. Classification method initiated by Batten (1996) was employed and one different palynofacie intervals were identified in the studied well. Frequency distributions of dispersed organic matter in the well is given in Figure 2 and different

palynofacies encountered in the wells are given (Table 1). Different palynofacies intervals encountered in the well based on the nature of organic matter and their source are as follows:

4.2.1 HA – 001 Palynofacies Interval: 750-11610 ft

Abundance of Amorphous Organic Matter (AOM) is recognized throughout this interval in HA 001 well. It is characterized by AOM which ranges from 23.44 - 87.38%, followed by palynomorphs 2.91 - 69.53%, opaque 3.27-23.7% and phytoclasts 1.1 – 11.67%. There is common to abundant occurrences of poorly sorted, small to large AOM with small to common occurrence of poorly sorted small to medium size phytoclasts and opaques. Moderate occurrences of *Zonocostites ramonae* were also recorded.

4.3 Palaeoenvironment of Deposition

Tyson (1984, 1995) describe a ternary diagram of kerogen plot consisting the AOM, phytoclasts and palynomorphs. Mesozoic-Cenozoic rocks have been studied and the ternary plots have palynological kerogen with similar composition and paleoenvironmental setting occupying the same field. The interpretation of each palynofacies field is shown in table 2. The kerogen percentage and their representative field in ternary diagram of the studied well is shown table 1 and figure 3. Relative proximity of terrestrial organic matter sources, kerogen transport ways, and the redox states of the depositional environments determine the AOM preservation are indicated on the resultant palynofacies ternary plot. Oxic-anoxic conditions (Al-Ameri *et al.,* 1999) have been reflected by this plot therefore the variation in oxygenation status of the depositional environment is determined. The percentage frequencies of AOM, phytoclast and palynomorphs were plotted for HA-001 well (Figure 3) using MS Excel and Surfer 9 software and their occurrences is compared with the fields of ternary diagram (Tyson, 1995) which inferred the environment of deposition for the studied well. Most of the distribution of the well came under the zone VII and VIII area which indicated distal dysoxic-anoxic shelf while only few frequencies are gathered in zone V and IX which is a signature for mud dominated shelf (distal shelf) and distal suboxic-anoxic basin respectively in deposition of the sediments in HA-001 well.

Table 1: Different Palynofacies in HA-001 Well

S/N	DEPTH	AOM(%)	PHYTOCLASTS(%)	OPAQUE(%)	PALYNOMORPHS(%)
1	750	58.92	-	8.42	32.66
2	900	41.87	-	5.98	52.15
3	1050	27.82	1.64	3.27	67.27
4	1200	51.36	3.02	6.04	39.58
5	1350	56.82	3.79	15.15	24.24
6	1500	59.43	4.1	16.39	18.03
7	1650	62.24	4.15	16.59	17.01
8	1800	59.62	3.85	13.46	23.07
9	1950	23.44	1.56	5.47	69.53
10	2100	25.04	1.62	5.65	67.69

11	2400	31.66	1.1	10.91	56.33
12	2550	43.03	2.97	13.35	40.65
13	2700	43.34	1.55	13.93	41.17
14	2835	41.67	-	12.1	46.24
15	3000	58.94	1.90	15.21	23.95
16	3150	47.11	1.52	12.16	39.21
17	3300	54.79	-	10.27	34.93
18	3450	62	-	18	20
19	3600	70.79	-	17.7	11.50
20	3750	43.99	-	14.66	41.35
21	3900	48.95	-	20.98	30.07
22	4050	56.68	2.02	22.27	19.03
23	4200	68.97	-	17.24	13.79
24	4350	71.11	2.22	15.56	11.11
25	4500	62.76	-	20.92	16.32
26	4650	67.87	-	22.62	9.51
27	4725	60.93	-	10.75	28.32
28	4800	71.73	-	12.66	15.61
29	4875	69.26	-	17.32	13.42
30	4950	75.56	-	13.33	11.11
31	5025	75.83	-	18.96	5.21
32	6000	68	-	12	20
33	6300	50.58	11.67	15.56	22.18
34	6600	46.1	7.1	17.73	29.07
35	6750	50.36	9	12.59	28.05
36	8700	33.4	2.08	6.26	58.26
37	8775	51.83	3.05	6.1	39.02
38	8850	61.6	3.58	7.17	28.32
39	8925	52.15	3.07	6.13	38.65
40	9000	42.11	5.26	5.26	47.37
41	9075	59.7	3.73	3.73	25.37
42	9150	48.93	3.05	9.17	38.84
43	9225	63	7.87	7.87	21.26
44	9300	60.7	3.57	7.14	28.57

45	9375	76.6	-	8.51	14.89
46	9450	63.9	-	11.28	24.81
47	9525	70.83	4.17	8.33	16.67
48	9600	53.16	3.32	9.96	33.55
49	9675	65.84	-	16.46	17.7
50	9750	72.07	4.5	13.5	9.9
51	9825	72.65	4.27	8.54	14.53
52	9900	76.92	-	8.54	14.53
53	9975	74.56	-	13.16	12.28
54	10050	67.57	4.50	18.02	9.90
55	10125	73.73	-	18.43	7.83
56	10200	71.12	2.16	12.93	13.79
57	10275	83.33	-	9.25	7.4
58	10350	74.24	4.37	8.73	12.66
59	10425	76.58	2.25	11.26	9.91
60	10500	76.23	-	13.45	10.31
61	10575	71.1	-	23.7	5.21
62	10650	70.1	2.34	21.03	6.54
63	10725	73.06	-	18.26	8.68
64	10800	77.63	-	13.7	8.68
65	10875	75.56	-	13.33	11.11
66	10950	87.38	-	9.70	2.91
67	11025	79.44	2.34	11.68	6.54
68	11100	75.47	-	18.87	5.66
69	11175	79.81	2.35	11.74	6.10
70	11250	76.92	-	13.57	9.50
71	11325	80.19	-	14.15	5.66
72	11400	71.11	4.44	13.33	11.11
73	11475	77.63	-	13.7	8.67
74	11550	79.81	-	14.08	6.10
75	11610	81.34	-	14.35	4.31

Table 2: The Interpretation of Palynofacies Field

Palynofacies Field	Environment	Kerogen Type
I	Highly proximal shelf or basin	III, gas prone
II	Marginal dysoxic-anoxic basin	III, gas prone
III	Heterolithic oxix shelf ('proximal shelf')	III or IV, gas prone
Iva	Dysoxic-suboxic shelf or basin transition	III or II, mainly gas prone
IVb	Suboxic-anoxic shelf or basin transition	III or II, mainly gas prone
V	Mud-dominated oxic shelf ('distal shelf')	III>IV, gas prone
VI	Proximal suboxic-anoxic shelf	II, oil prone
VII	Distal dysoxic-anoxic shelf	II, oil prone
VIII	Distal dysoxic-anoxic shelf	II>>I oil prone
IX	Distal suboxic-anoxic basin	II≥I, highly oil prone

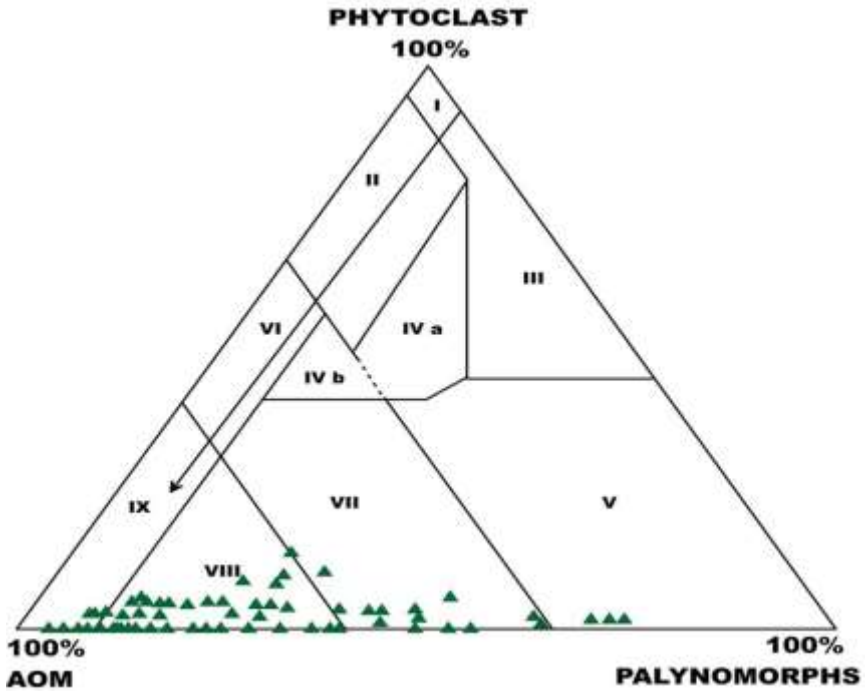

Figure 3: Palynofacies of HA-001 Well in the Ternary Kerogen Plot (Modified after Tyson, 1995)

5.0 Conclusion

Palynofacies analysis of seventy-five samples of HA-001 well located in Shallow Offshore Niger Delta within depth intervals of 750 – 11610 ft was processed and analysed. The environment of deposition of the studied well was carried out. Palynofacies analysis showed the dominance of land phytoclast, amorphous matter and miospores over marine palynomorphs. Palynomacerals I and II were abundant while Palynomacerals III and IV gave few occurrences. The ternary plot diagram of kerogen indicated deposition in distal dysoxic-anoxic shelf.

References

Al-Ameri, T. K, Al-Musawi, F. S. & Batten, D. J. (1999). Palynofacies indications of depositional environments and source potential for hydrocarbons: uppermost Jurassic-basal Creataceous Sulaiy Formation, southern Iraq. Cretaceous Research 20 (3), 359-363.

Atta-Petters, D, Achaegakwo, C. A, Kwayisi, D. & Garrey, P. (2015). Palynofacies and source rock potential of the ST-7H well, offshore Tano basin, western region, Ghana. *Earth Sciences*, Vol. 4, No. 1, 1 – 20. Doi:10.11648/j.earth.20150401.11.

Batten, D. J. (1996). Palynofacies and paleoenvironmental interpretation. Palynology: Principles and applications, 3, 1011-1064.

Batten, D. J. & Stead, D. T., (2005). Palynofacies analysis and its stratigraphic and its stratigraphic application. In: E. A. M. Koutsoukos (Ed), *Applied stratigraphy*, Netherland, Springer. 203-226.

Bostick, N. H., (1991). Thermal alteration of clastic organic particles as an indicator of contact and burial metamorphism in sedimentary rocks. *Geoscience and Man*, 3, 83-92.

Brooks. J., (1981). Organic maturation of sedimentary organic matter and petroleum exploration: a review, IN: Brooks, J. (Ed), *Organic Maturation and Fossil Fuel Exploration, Academic Press*, London, 1-37.

Combaz, A. (1964). Les palynofacies. *Revue de Micropaléontologie*, 7. 205-218.

Combaz, A. (1980). Les kerogenes vus au microscope. In: Durand, B. (Ed.) kerogen: Insoluble Organic Matter from Sedimentary Rocks. *Editions Technip*, Paris. 55-111.

Doust H. & Omatsola E., (1990). Niger Delta. [in:] Edwards J.D. & Santogrossi P.A., Divergent/Passive Margin Basins, AAPG Memoir, 48, American Association of Petroleum Geologists, Tulsa, 239–248.

Durand, B., (1980). Sedimentary Organic matter and kerogen. Definition and quantitative importance of kerogen. In: Durand, B. (Ed) Kerogen: Insoluble Organic Matter From Sedimentary Rocks. *Editions Technip*, Paris, 13-34.

Jansonius, J. & McGregor, D. C. (1996). Palynology, principles and applications. *American Association of Stratigraphic Palynologists Foundation*. ISBN 0931871034.

Lorente, M. (1990). Textural characteristics of Organic matter in several subenvironments of the Orinoco Upper Delta. *Geologie en Mijnbouw*; 69, 263-278.

Lucas, F. A. & Ebahili, E. O. (2017). Palynofacies studies of sedimentary succession in Ogbabu-I well, Anambra Basin, Nigeria. *Journal of Applied Science and Environmental Management* 21 (1): 156 – 167.

Traverse, A. (2007). Differential sorting of Palynomorphs into sediments: Palynofacies, palynodebris, discordant palynomorphs. Springer.

Tyson, R. V. (1984). Palynofacies investigation of Callovian (Middle Jurassic) sediments from DSDP site 534, Blake-Bahama Basin, western Central Atlantic. Marine and Petroleum Geology, 1, 3-13.

Tyson, R. (1995). Sedimentary organic matter: organic facies and palynofacies. *Chapman and Hall*, London, New York.

Van der Zwan, C. (1990). Palynostratigraphy and palynofacies reconstruction of the Upper Jurassic to lowermost Cretaceous of the Draugen Field, offshore Mid Norway. *Review of Palaeobotany and Palynology*, 62, 157-186.