

FORMATION EVALUATION OF “H” FIELD, IN THE NIGER DELTA REGION, NIGERIA

ABSTRACT

Based on data from two wells, a formation evaluation was performed on the "H" field (Niger Delta Region) to locate hydrocarbon-yielding reservoirs and examine reservoir characteristics. Techlog software was used to analyze the geophysical logs, i.e., Gamma Ray log, Resistivity log, Spontaneous Potential log, Neutron log, and Density log. It was found conclusively that porosity range from 24% - to 32%; thickness of the oil/gas-bearing zone range from 4m – to 11m; hydrocarbon saturation of oil/gas bearing sand range from 55% - 88%, and the permeability of oil/gas bearing zone range from 100md – 2900md in WELL 1 and 160 – 2900md in WELL 2. The depth of oil/gas accumulation was found to range from (2731 – 2755)m to (2853 – 2864)m in WELL 1 and (2755 – 2759)m to (2853 – 2864)m, and the amount of oil/gas contained in WELL 1 is 78869198.09 barrels and 735059345.7 cubic feet while WELL 2 contains 56105714.12 barrels and 735089345.7 cubic feet respectively. This shows that the hydrocarbon (oil/gas) was found within the middle and bottom of the Agbada formation.

Keywords—Formation Evaluation, Techlog software, Geophysical Logs, Hydrocarbon Saturation

1. INTRODUCTION

The sixth-largest province in terms of land area and known oil and gas reserves is the Niger Delta. Every day, the Basin produces about 2 million barrels of oil. It is expected to hold 34.5 billion barrels of oil, 94 trillion cubic feet of natural gas. It is a significant oil producer in the world.

The Province, is an extensional rift basin located on the passive continental margin of Nigeria's western coast, near the Niger Delta and the Gulf of Guinea, with speculated or verified access to Cameroon, Equatorial Guinea and São Tomé. The Niger delta basin is one of Africa's biggest subaerial basins. It has a total area of 300,000 km², 75,000 km² subaerial area, and 500,000 km² sediment fill. The sediment layer is between 9 and 12 kilometers deep. It consists of various diverse geologic formations that reveal the regional and continental tectonics of the area as well as how this basin may have formed. An extensional basin, the Niger Delta Basin is surrounded by several other basins formed through related processes. The Benue Trough, a larger tectonic structure, contains the Niger Delta Basin in its southernmost region. A failed rift junction produced the Niger Delta Basin as the South American plate separated from the African plate, and the South Atlantic began to

expand. This basin rifting began in the late Jurassic and finished in the mid-Cretaceous. Many faults, including some thrust faults, emerged as the rifting progressed. Sands from the syn-rift and later shales were also deposited in the late Cretaceous. This implies that the coastline shrank during this time. There was a large coastline transgression at the start of the Paleocene. The Paleocene saw the formation of the Akata Formation, which was followed by the Eocene and the Agbada Formation. Due to this loading, the underlying shale Akata Formation was compressed into shale diapirs. The Benin formation, which is still being formed today, was then deposited in the Oligocene. Because of its tectonic nature, the basin is divided into many zones.

The Paleocene is when the Akata Formation was formed. Thick shales, turbidite sands, and a small amount of silt and clay make up its composition. It began in anoxic conditions and at relative sea level low stands. The thickness of this structure could reach 7,000 meters. The Eocene era saw the formation of the Agbada Formation. It is a marine facies that combines characteristics of deep sea and freshwater. This is the basin's primary oil and natural gas bearing facies. The rock in this layer became subaerial and was buried in an organically

rich marsh environment, which is where the hydrocarbons in this layer came from. It is thought to be 3,700 meters thick. The Benin Formation is oligocene in age and younger. Sands from the continental floodplain and alluvial deposits make up its composition. It could measure 2,000 meters thick.

The sediment fill of the Niger Delta basin is divided into three distinct depobelts. These three cycles show that the basin generally regressed over time as sediments changed from fluvial heavier sand-sized grains to deep sea mud-sized grains. Due to a number of factors, the lithologies of the region change. Sediment from the onshore highlands that flows into the delta regulates the mineralogy of the grains. Furthermore, it is well known that the relative sea level determines how much sediment is deposited; lithologies will migrate basinward in response to the relative sea level. On a concave coastline, an environment dominated by tides is thought to have deposited the early Cretaceous sediments. The shoreline, however, became convex over time and is now a wave-dominated system. Although the tectonic characteristics (structures) of the Niger Delta Basin are typical of an extensional rift system, the addition of shale diapirism caused by stress makes it unique.

An estimate of fluid content, porosity, lithology, and type will be possible through formation evaluation in the study area of the Niger Delta Basin. This method of measuring the physical and chemical properties of the rock is very effective in defining subsurface geology. Reservoir characterization aims to develop a geological model that incorporates the data at hand and can be used to forecast how porosity, permeability, and fluid distribution will be distributed throughout the field operation. Archie stated that a broad relationship exists between porosity and the permeability of a formation. The study's major goals are to evaluate the reservoir rocks in the "H" field using wireline log techniques, to determine the petrophysical parameters using the Archies formation, and to correlate the wells in the study area.

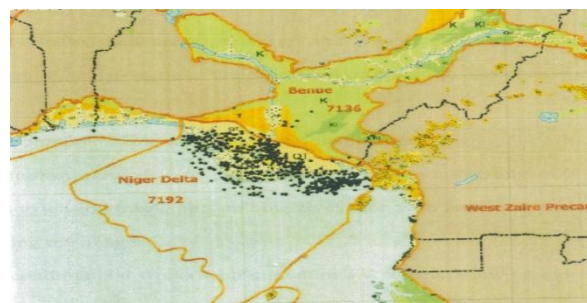


Fig 1.1: Geologic map of the Niger Delta Basin and the Benue trough and the oil fields in the region.



Fig 1.2: The Niger Delta Basin is located in the Gulf of Guinea on the west coast of Africa

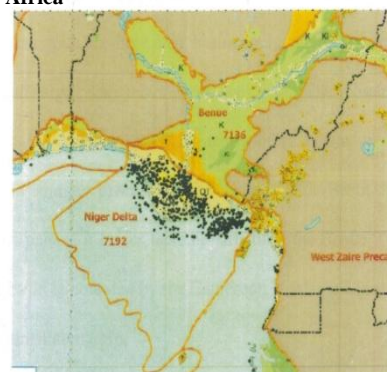


Fig 1.3: Geologic map of the Niger Delta and the Benue trough, and the oil fields in the region.

LITHOLOGY

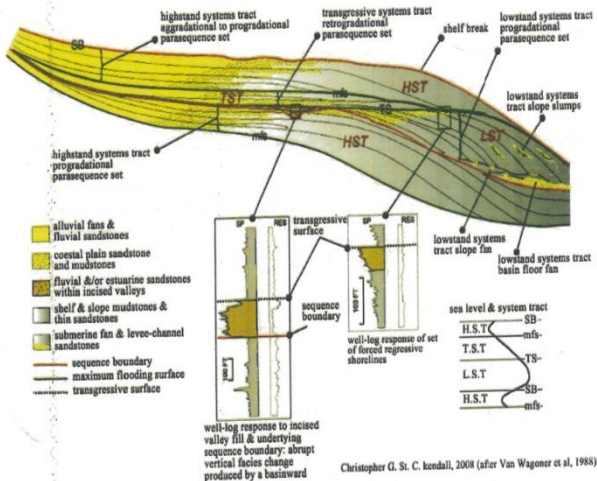


Fig 1.4: Sea level highstand and lowstand mapped on a crosssection of the basin

PETROLEUM

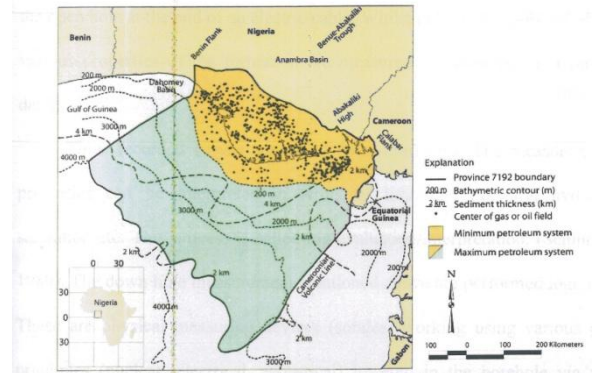


Figure 1: Index map of Nigeria and Cameroon. Map of the Niger Delta showing Province outline (maximum petroleum system); bounding structural features; minimum petroleum system as defined by oil and gas field center points (data from Petroconsultants, 1996a); 200, 2000, 3000, and 4000 m bathymetric contours; and 2 and 4 km sediment thickness.

Fig 1.7: Map of the Niger Delta showing province outline (max. petroleum system).

TECTONIC STRUCTURE

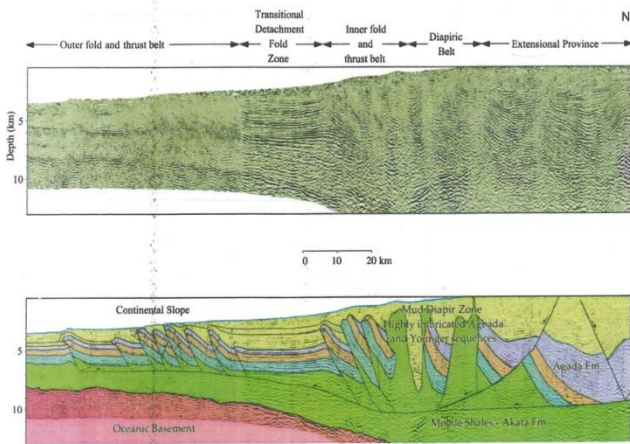


Fig 1.5: Tectonic Structures drawn over a seismic profile of the Niger Delta Basin

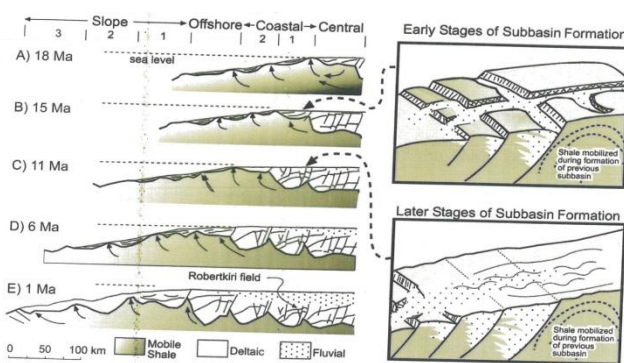


Fig1.6: Evolution of Niger Delta subbasins as mobile shales migrate towards the continental slope

2. MATERIALS AND METHODS

The resources used for the Formation Evaluation of the wells are Techlog software, Resistivity log, Gamma Ray log, Spontaneous Potential log, Density log, and Neutron log. Techlog software, a wellbore-centric petrophysical application composed of a platform and a set of add-on-application segments was used to analyse the geophysical logs. Resistivity logs helped in determining the hydrocarbon versus water-bearing zones, Indicate permeable zones and calculate the resistivity porosity. The reservoir fluids were characterized by neutron-porosity and bulk density logs. The percentage of shale and, consequently, the predominant lithology were determined using the gamma-ray index. This was done by identifying the clean sand line using gamma-ray records. The unconsolidated sand in the Niger.

ii ARCHIE'S EQUATION

water saturation in all the clean sands were evaluated using Archie's equation

$$(S_w)^n = FR_w/R_t$$

$$(S_w) = \sqrt[n]{FR_w/R_t}$$

Where $F = a/\phi^m$

$$R_w = R_0/F$$

$$\text{So, } S_w = \left(\frac{R_0}{R_t}\right)^{1/n} = \left(\frac{F X R_w}{R_t}\right)^{1/n}$$

$$\therefore S_w = \left(\frac{\alpha X R_w}{R_t X \phi^m}\right)^{1/n}$$

Where:

S_w = Water of saturation

F = Formation factor

a = Tortuosity factor (often taken to be 1)

m = Cementation factor (varies around 2)

R_w = Resistivity of formation water

R_t = True formation resistivity as measured by deep reading resistivity log

R_0 = Resistivity of the water/saturation formation

n = saturation exponent (most commonly 2)

ϕ = Porosity

R_{sh} = Resistivity of shale

V_{sh} = Volume of shale

Delta was taken into account when correcting the gamma-ray index.

i. SIMANDOUX EQUATION FOR SATURATION DETERMINATION

Simandoux equation was used to assess the impact of shale with regards to waters capacity.

$$1/R_t = \frac{(S_w)^2}{F X R_w(1-V_{sh})} + \frac{S_w \times V_{sh}}{R_{sh}}$$

Shaly Sand

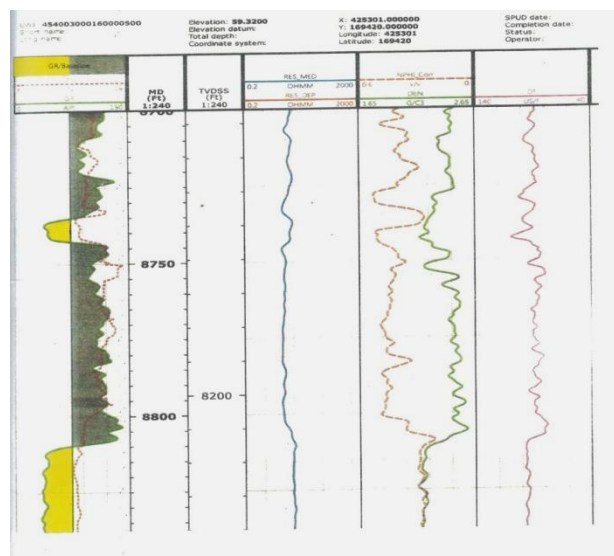
$$1/R_t = \frac{V_{sh}}{R_{sh}} + \frac{1-V_{sh}}{R_{sh}}$$

$$S_w = \frac{\alpha \times R_w}{2 \times \phi} \left[\sqrt{\frac{4 \times \phi}{\alpha \times R_w \times R_t}} \times \frac{V_{sh}}{R_{sh}} - \frac{V_{sh}}{V_{sh}} \right]$$

3. RESULTS AND DISCUSSION

Qualitative Interpretation of Well Logs

From the Formation Evaluation of the WELLS, the following results i.e. lithology, petrophysical and volumetric data are hereby presented in tables (1-6) and figure 1.8



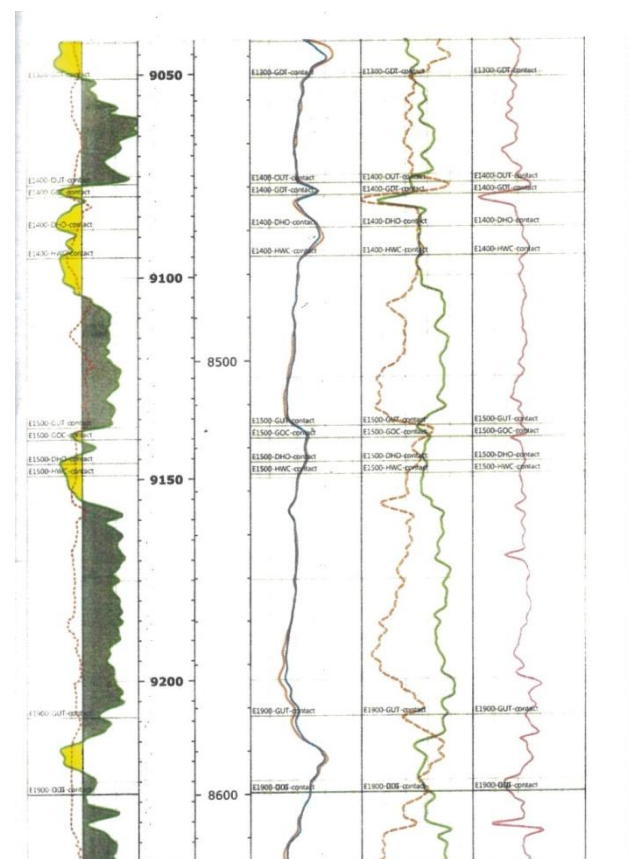
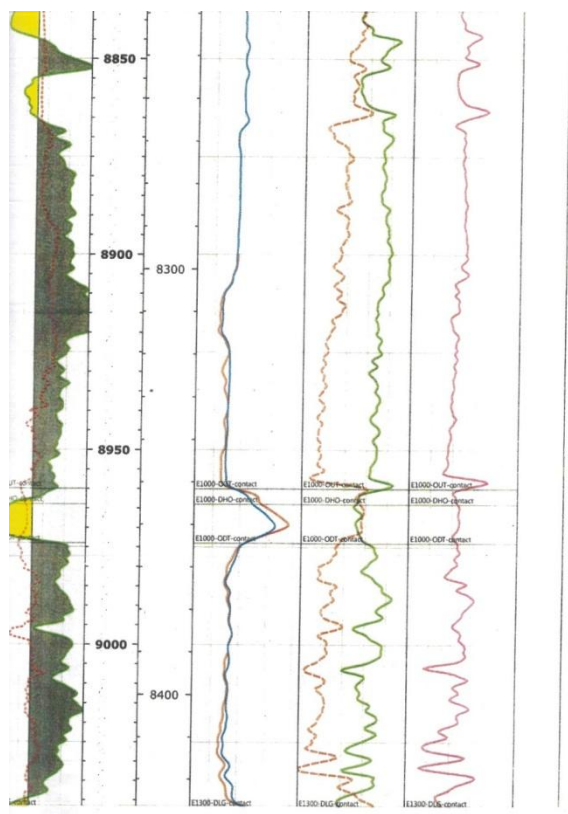


Figure 1.8: Cross section of the Evaluated Petrophysical Logs

(i) Lithology

Table 1: WELL 1 Lithology

Reservoir interval (m)	Lithology	Remark
2652 – 2662	Shale	Shale
2662 – 2665	Sand	Water bearing formation
2665 – 2684	Shale	Shale
2684 – 2696	Sand	Water bearing formation
2696 – 2698	Shale	Shale
2698 – 2703	Sand	Water bearing formation
2703 – 2731	Shale	Shale
2731 – 2735	Sand	Oil bearing formation
2735 – 2755	Shale	Shale
2755 – 2759	Sand	Gas bearing formation
2759 – 2767	Shale	Shale
2767 – 2775	Sand	Gas, oil and water formation
2775 – 2785	Shale	Shale
2785 – 2791	Sand	Water bearing formation
2791 – 2809	Sand	Shale
2809 – 2811	Sand	Gas bearing formation
2811 – 2828	Shale	Shale
2828 – 2838	Sand	Gas and oil bearing formation
2838 – 2853	Shaly sand	Shale
2853 – 2864	Sand	Gas and oil formation
2864 – 2867	Shale	Shale
2867 – 2871	Sand	Water bearing formation
2871 – 2873	Shale	Shale
2873 – 2890	Sandy shale	Water bearing formation
2890 – 2903	Shale	Shale
2903 – 2979	Sand	Water bearing formation

Table 2: WELL 2 Lithology

Reservoir interval (m)	Lithology	Remark
2708-2755	Shale	Shale
2755-2759	Sand	Gas bearing formation
2759-2767	Shale	Shale
2767-2775	Sand	Water bearing formation
2775-2785	Shale	Shale
2785-2791	Sand	Water bearing formation though with relatively high resistivity
2791-2809	Shale	Shale
2809-2811	Sand	Gas bearing formation
2811-2828	Shale	Shale
2828-2838	Sand	Gas and oil bearing formation
2838-2853	Shale	Shale
2853-2864	Sand	Gas and oil bearing formation
2864- 2867	Shale	Shale
2867-2890	Sandy shale	Water bearing formation
2890-2918	Shale	Shale
2918-2980	Sandy shale	Water bearing formation

(ii) PETROPHYSICAL ANALYSIS

Table 3: WELL 1 PETROPHYSICAL ANALYSIS

Reservoir Interval (m)	GR (API)	Net Thickness (m)	R _t (Ω-m)	P (g/cm ³)	Ø	S _w	S _h	Remark
2662 – 2665	45	3	20	2.23	0.25	1.0	0.0	Water
2684 – 2696	39	12	20	2.21	0.27	1.0	0.0	Water
2698 – 2703	60	5	20	2.17	0.29	1.0	0.0	Water
2731 – 2735	36	4	1280	2.17	0.26	0.13	0.87	Oil
2755 – 2759	42	4	1200	2.05	0.32	0.13	0.87	Gas
2767 – 2775	45	8	1000	2.17	0.26	0.14	0.86	Gas
2785 – 2791	54	6	100	2.23	0.25	0.45	0.55	Gas/oil
2809 – 2811	45	2	1200	2.15	0.27	0.13	0.87	Gas
2828 – 2838	39	10	1400	2.21	0.24	0.13	0.88	Gas/oil
2853 – 2864	42	11	1200	2.21	0.27	0.1	0.0	Water
2867 – 2871	39	4	20	2.21	0.27	0.1	0.0	Water
2873 – 2890	30	17	20	2.25	0.24	1.0	0.0	Water
2903 – 2979	27	76	20	2.21	0.27	1.0	0.0	Water

Table 4: WELL 2 PETROPHYSICAL ANALYSIS

Reservoir Interval (ft)	Reservoir Interval (m)	GR (API)	Net Thickness (m)	R _t (Ω-m)	P (g/cm ³)	Ø	S _w	S _h	Remark
9039 – 9053	2755 – 2759	42	4	1200	2.05	0.32	0.13	0.87	Gas
9077 – 9105	2767 – 2775	45	8	1000	2.17	0.29	0.14	0.86	Gas
9136 – 9157	2785 – 2791	48	6	100	2.19	0.28	0.45	0.55	Gas/oil
9215 – 9224	2809 – 2811	45	2	1200	2.17	0.26	0.13	0.87	Gas
9278 – 9310	2828 – 2838	41	10	1400	2.21	0.24	0.12	0.88	Gas/oil
9360 – 9395	2853 – 2864	45	11	1200	2.21	0.24	0.13	0.87	Water
9405 – 9482	2867 – 2890	30	23	20	2.25	0.24	1.0	0.0	Water
9574 – 9776	2918 – 2980	37	62	20	2.23	0.25	1.0	0.0	Water

(iii) DATA EVALUATION

Table 5: WELL 1 DATA EVALUATION

Reservoir Interval (ft)	GR (API)	Net thickness (m)	R _t (Ω - m)	P (g/cm ³)	Ø	S _w	S _h	K(md)	Remark
2731 – 2733	36	4	4	1280	2.17	0.26	0.13	0.87	Oil
2755 – 2759	42	4	1220	2.05	0.32	0.13	0.87	2900	Gas
2767 – 2775	45	8	1000	2.17	0.26	0.14	0.86	1000	Gas
2785 – 2791	54	6	100	2.23	0.25	0.45	0.55	100	Gas / Oil
2809 – 2811	45	2	1240	2.15	0.27	0.13	0.87	1500	Gas
2828 – 2838	39	10	1400	2.21	0.24	0.13	0.88	1000	Gas /Oil
2853 – 2864	42	11	1200	2.21	0.27	0.1	0.0	900	Gas / Oil

Table 6: WELL 2 DATA EVALUATION

Reservoir Interval (ft)	GR (API)	Net thickness (m)	R _t (Ω - m)	P (g/cm ³)	Ø	S _w	S _h	K(md)	Remark
2755 – 2759	42	4	1200	2.05	0.32	0.13	0.87	2900	Gas
2767 – 2791	45	8	1000	2.17	0.26	0.14	0.86	1000	Gas
2785 – 2791	48	6	100	2.19	0.28	0.45	0.55	160	Gas/Oil
2809 – 2811	45	2	1200	2.17	0.26	0.13	0.87	1200	Gas
2828 – 2938	39	10	1400	2.21	0.24	0.12	0.88	1000	Gas/Oil
2853 – 2864	45	11	1200	2.21	0.24	0.13	0.87	900	Gas/Oil

VOLUME OF HYDROCARBON IN-PLACE

$$\text{Vol. of Hc}_{ip} = k \sum_{n=1}^{\infty} Ah(1 - S_w) \emptyset$$

Well 1

Oil = 78869198.09 barrels

Gas = 735059345.7 cubic feet

Well 2

Oil = 56105714.12 barrels

Gas = 735089345.7 cubic feet

4. CONCLUSION

In this project, the Simandoux Equation was used to determine the effect of shale on water saturation. Archie's Equation was also used to evaluate the water saturation in all the clean sands. The Techlog software was used to analyze the geophysical logs. The data from the two wells was adequate to enable extensive study, including porosity, hydrocarbon saturation, permeability, and depth. The lithology is composed of an alternating series of sands and shales, according to the GR and SP logs examination. It is therefore recommended that the "H" (field Niger Delta Region) contains enough hydrocarbons that can be extracted based on the quantitative and qualitative interpretation of the area. For a more precise evaluation of a specific oil well, these factors should be thoroughly checked using core drilling to confirm the findings of wireline logging. Parameters should be carefully examined to better evaluate a given oil well.

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