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APPLICATION OF THE UNITED NATIONS FRAMEWORK CLASSIFICATION TO ASSESSMENT OF THE PROSPECTIVE RESOURCES OF HYDROCARBONS IN AZERBAIJAN

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A B S T R A C T

The oil and gas industry plays an important role in Azerbaijan's economy, contributing significantly to GDP and government revenues. However, the existing classification of hydrocarbon reserves and resources is outdated and does not reflect the economic efficiency of extraction. In this regard, the United Nations Framework Classification for Resources (UNFC) helps to determine the feasibility, technical viability, and maturity of resource development projects. This paper examines the assessment of hydrocarbon resource categories by comparing the current classification system for oil and gas reserves and resources in Azerbaijan with the UNFC. The objective of this work is to conduct a comparative analysis of prospective resource categories and thus provide a basis for the preparation of a bridge document describing the relationship between the United Nations Framework Classification and the existing 1984 classification used in Azerbaijan. To conduct this research, a hypothetical field called «Structure C» was used in which resource assessments were conducted at various times in 1984, 1988, 1993, 2001, and 2011 based on the 1984 classification of the former Soviet Union.

Keywords: prospective resources of hydrocarbons; UN framework classification; case study.

1. Introduction

Oil and gas production is a crucial component of Azerbaijan's economy, contributing significantly to its GDP, government revenues, and export earnings. It also attracts substantial foreign investment and promotes infrastructure development, such as the establishment of terminals, pipelines, and export routes to deliver oil and gas to global markets.

Revenues from oil and gas exports play a crucial role in financing various sectors of the economy, such as education, healthcare, and social security. They also contribute to economic diversification and job creation for the population.

Moreover, Azerbaijan's oil and gas industry stimulates the development of related sectors such as petrochemicals, engineering services, and construction, creating a multiplier effect on the economy.

However, one may ask: what is the extent of the country's oil, gas, and gas condensate reserves?

The answer to this question is ambiguous because there is a significant amount of hydrocarbon raw materials in the country's subsurface, which are known to exist but are currently either technologically impossible or economically ineffective to produce. These resources cannot be accounted for in the reserve base. However, with the development of technology, it may be possible to increase the volume of recoverable reserves and enable commercial production. Azerbaijan's hydrocarbon prospective resources offer significant opportunities for further exploration and development, contributing to the country's economic growth and energy security. To unlock the full potential of these reserves, continued investment in exploration activities and technological innovation is crucial.

Effective management and precise accounting of a nation's resources are also essential for ensuring long-term sustainability. There are various classifications of reserves and resources that categorize them based on different characteristics and criteria. However, the Former Soviet Union Classification adopted in 1984 for estimating and reporting petroleum reserves and resources, which is currently used in Azerbaijan, known for simplicity as AR-1984, is considered technically outdated. It does not take into consideration the economic viability of development and production. Thus, there is an immediate necessity to either create our own classification system or switch to established international standards for categorizing hydrocarbon reserves.

The classification of hydrocarbon reserves should enable a transition from administrative regulation of underground usage to a mechanism based on geological-economic and technical-economic evaluations of the feasibility of developing hydrocarbon reserves, while also addressing environmental

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concerns. The main goal is to improve reserve reliability, simplify the reserve approval process, reduce administrative obstacles, take a comprehensive approach to administrative-benefit parameters, improve government regulatory mechanisms to promote the development of inefficient and hard-to-recover reserves and conform to international methodologies, among other objectives. The United Nations Framework Classification for Resources (UNFC) is one of the reserve classification systems accepted in the industry [1].

The UNFC is a globally recognized and internationally applicable system for classifying resources and reserves based on projects and principles. It is designed to determine the ecological-social-economic viability, technical feasibility, and maturity of resource development projects. The main categories in the classification are defined objectively and are complemented by general and specific product characteristics. These categories are used in conjunction with a code-numeric system, providing a wide range of applications and comparable decision support across various energy sources [2].

To date, several countries, such as China, Russia, Norway, etc., have already developed bridging documents to align their national classification systems with the UNFC [3-6], and Ukraine has adapted its national mineral resource classification system and uses the UNFC as a universal system for calculating mineral reserves/resources [7].

The UNFC resource classification system assesses the environmental and socio-economic viability, technical feasibility, and maturity of resource development projects. It uses a numerical coding system based on three main criteria: environmental and socio-economic viability (E), technical feasibility (F), and degree of confidence in the assessment (G). These criteria combine to create a three-dimensional system (fig.1).

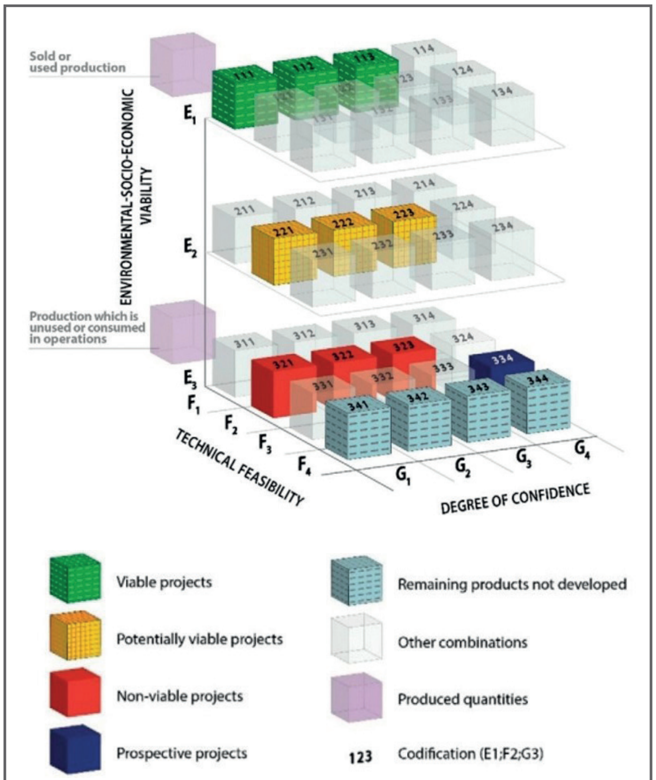

Fig. 1. UNFC categories and examples of classes [1]

In AR-1984, oil and gas reserves are classified based on their technical development and the degree of geological knowledge (fig. 2).

Under the Azerbaijan Science Foundation›s grant EIF/MQM/ETS-2020-1(35) in the ‹Science-Education-Industry› section for the period of 2021-2023, there is an ongoing examination of the potential to reclassify the country›s hydrocarbon resources using the aforementioned classification framework.

To enhance the classification of Azerbaijan›s hydrocarbon resources and reserves, a comparative analysis of AR-1984, UNFC, and Society of Petroleum Engineers Petroleum Resource Management Systems (SPE/PRMS or PRMS) is required, as per the research project plan. Previous publications have shown the main reserve categories in UNFC and AR-1984 classifications to be aligned [9].

This work focuses on prospective resource categories. The UNFC classification categorizes prospective resources as E3, F3, and G4, while the AR-1984 classification uses C3, D1, and D2 categories. This paper discusses the potential for linking categories from the United Nations Framework Classification of Fossil Energy and Mineral Reserves and Resources and the current Reserves and Resources Classification in Azerbaijan 1984. The aim is to create a bridging document that describes the relationship between the two classifications.

The UNFC E3 category refers to the environmental and socio-economic category for resources where there is no realistic prospect for producing viable products in the near future. This category indicates that the project either does not have economic or environmental viability, or that significant barriers, restrictions, or negative impacts make its implementation impossible or impractical in the coming years.

The E3 category has subcategories, namely E3.1, E3.2, and E3.3, which are defined and described in the main document [1]. However, they are used differently compared to the other subcategories. For instance, E3.1 determines the volume of products that are forecast to be produced but not subsequently used or consumed during operation. On the other hand, E3.2 classifies the volumes of both prospective and forecast exploration resources and potentially viable projects. Additional volumes in the reservoir and volumes of non-viable projects are assigned to subcategory E3.3. For our study, we only use subcategory E3.2.

The UNFC F3 category indicates the technical feasibility and maturity of the prospect. For a more detailed description of this category, refer to the document ‹Supplementary Specifications for the Application of the United Nations Framework Classification of Petroleum Resources.› Due to

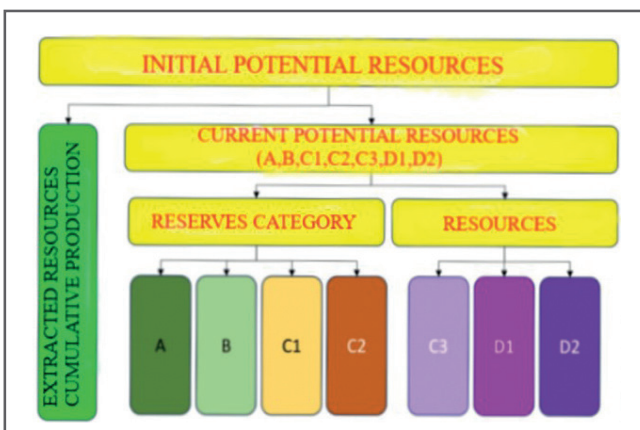

Fig. 2. Classification of reserves and resources of oil and gas, AR-1984 [8]

limitations in technical data, it is not possible to assess the production feasibility of a particular development project. Preliminary studies based on a specific development project should be used to determine the likelihood of development. It is recommended to use subcategories F3.1, F3.2, and F3.3 to differentiate promising projects based on their level of maturity [10].

The subcategories of category F3 are defined in [3] as follows:

- F3.1: If «site-specific investigations have identified the potential resource source and product(s) with sufficient confidence to warrant further testing».
- F3.2: When «local studies indicate the potential for development in a specific area but require more data collection and/or evaluation in order to have sufficient confidence for further testing».
- F3.3: At the earliest stage of research, where favorable conditions for the potential discovery may be inferred from regional studies.

The UNFC G4: Estimation of potential deposit volumes based primarily on indirect data. Quantities estimated during the exploration phase are subject to a significant range of uncertainty, as well as a significant risk that the development project subsequently may not be implemented to produce the estimated quantities. If one estimate is provided, this should be the expected result, but where possible the full range of uncertainty should be documented, for example in the form of a probability distribution. When assessing risks, the evaluator must consider the likelihood and productivity of the formation. In accordance with the geological reliability the UNFC distinguishes subcategories as follows:

G4.1 – Low estimates of the quantities;

G4.2 – Incremental amount to G4.1+G4.2 equates to a best estimate of the quantities;

G4.3 – Incremental amount to G4.1+G4.2 such that G4.1+G4.2+G4.3 equates to a high estimates of the quantities.

According to AR-1984, undiscovered oil, gas, and condensate resources are divided into prospective C3 and forecast D1 and D2 categories based on the degree of their validity. Category C3 represents the volumes of resources confirmed by geological and geophysical studies in exploration areas ready for drilling. The thickness of the formation and filtration-capacity properties are taken by analogy with neighboring formations. Prospective resources are used in the planning of geological exploration activities and in the transition of reserves from categories C1 and C2 to C3.

Category D1 includes forecast oil and gas resources of lithological-stratigraphic complexes within large territories whose oil and gas bearingness remains to be ascertained.

Category D2 represents resource volumes within large unexplored regional lithological and stratigraphic units, whose appraisal is based on geological, geophysical and geochemical evidences from neighboring petroliferous regions. Normally, D1 and D2 resource prediction is carried out for poorly studied large-scale regional tectonic or stratigraphic units (subunits) of sedimentary basins.

2. Methodology

A case study approach is used to establish a link between UNFC and AR-1984 resource categories.

Resource and reserve assessments for the conditional «Structure C» oil field located offshore south of Baku city were conducted at various intervals in 1984, 1988, 1993, 2001 and 2011 in accordance with AR-1984.

«Structure C» is located in a relatively deep-water section of the South Caspian shelf. Seismic surveys have been conducted in this area over the years. In the late 1950s and early 1960s, seismic exploration using the reflected wave method identified a structural uplift. Between 1983 and 1991 explorationists used the common depth point method to delineate the structure and construct structural maps on regionally-persistent seismic horizons. That the structure belonged to a proved oil and gas bearing region and the adjacent northern and northeastern structures were petroliferous indeed allowed the considered uplift to be related with a group of prospective structures. Subsequently, each new seismic survey served to a better understanding of the structural and tectonic characteristics of the uplift.

In the late 1990s extensive geological exploration was conducted in this area. A large structure of asymmetric brachyanticline shape was revealed being NW-SE oriented then further turning southerly to take meridional direction. While the NW pericline of the fold is shorter in length and wider across, the southern pericline is narrow and elongated. On the deepest isodepth closure the structure is 32×7.5 km in size, with ranging from 1600 to 2100 m of vertical amplitude.

Mud diaprism played a significant role in shaping the structure. The angle of inclination of the limbs increases with depth. Within the dome of the structure no seismic data zone is observed, largely due to presence of a meridional fault line and mud volcanic body. Transverse faults are noted as well. Overall, the structure is syndepositional in its nature.

In terms of petroleum geology, any hydrocarbon resource assessment requires fulfilment of at least three principal conditions on a region in question. These conditions are presence of effective oil source rocks, availability of reservoir horizons and fluid screening layers over the potential accumulations. Based on the regional oil and gas occurrence picture and exploration experience, the major targets within the Lower Pliocene Productive Series (PS) were identified as the Fasila Suite (FS) and the Balakhany Suite's (BS) X and VIII horizons.

The first exploration well was drilled on the northern flank of the anticline in 2000s. The vertical well bore penetrated into potential reservoirs of the BS and the FS.

Within a depth range of 6000-7000 m the presence of FS at a thickness of 300 plus m was documented. The total thickness of sandy layers from the BS's VIII horizon to the bottom of the well surpassed expectations making up over 200 m. The FS, major reservoir in the section, was determined to have an effective thickness of 30 m (with porosity cut-off 12%) and minor gas and remnant oil saturation indications.

As «Structure C» meets the existing geological and geophysical assessment criteria on the AR-1984 its resources can be assigned to C3 category. The earliest seismic interpretation report of 1991 suggested an area of 143.7 km^2 based on delineation on the FS top (table 1). The next 2017 survey presented an almost unchanged (146.5 km^2) area, meanwhile a new prospective target – the Post-Kirmaky Suite of the PS lower division was added. The reduction in the C3 geological resources is explained by smaller effective thicknesses involved in calculations. The recent evaluation of 2020 was performed on the latest seismic sounding results that enabled drawing new structural geometry. This time significantly smaller area (52.2 km^2) was produced, however, the target objects increased in number (the Fasila, Supra Kirmaky Sandy, and Post Kirmaky Suites).

The structure discussed above is within an oil and gas bearing region «B» located in the Azerbaijan sector of the Caspian Sea. Currently, oil, gas, and gas condensate are produced at various fields. Typically, the productive reservoirs are deeply buried, accordingly, further prospects are likely to occur at great depths.

As the basin comes to be better understood and the knowledge of it widens, the forecast resource figures undergo certain changes. Table 2 illustrates the changes observed at region «B» since 1984.

Table 2 demonstrates significant changes in resource volumes readily seen by comparison of the figures of 1993 and 2001 assessment reports. The increased hydrocarbon resource potential of the basin is reflected on the figures of total estimated volumes (C3+D1+D2), which basically became quadrupled.

Table 1
C3 category hydrocarbon resources for «Structure C» presented over the years

Year	Stratigraphic unit	Area (км²)	Prospective resources, Category C3 (million tons)
1991	Fasila Suite	143.7	374
2017	Fasila and Post Kirmaky Suites	146.5	350
2020	Fasila, Supra Kirmaky Sandy and Post Kirmaky Suites	52.2	229

Table 2
Prospective C3 and forecast D1 and D2 HC resources over the years (as exemplified by the region «B» in the Azerbaijani Caspian Sea sector)

Year	Hydrocarbons	Undiscovered resources (mln.t.)			Total (mln. t.)*
		C3	D1	D2	
1984	Oil	260.8	163	11	434.8
	Dissolved gas	-	52	2	54
	Gas-condensate	-	105	-	105
	Free gas	29.4	343	14	386.4
	Total:	290.2	663	27	**980.2**
1988	Oil	65	264	-	329
	Dissolved gas	-	23	-	23
	Gas-condensate	45	7	-	52
	Free gas	183	35	-	218
	Total:	293	329	-	**622**
1993	Oil	81.4	48.4	16.6	146.4
	Dissolved gas	37.7	4.4	1.9	44
	Gas-condensate	56.4	92.3	-	148.7
	Free gas	228.8	446.5	31.3	706.6
	Total:	404.3	591.6	49.8	**1045.7**
2001	Oil	1433	100	55	1588
	Dissolved gas	20	15	4	39
	Gas-condensate	75	86	133	293
	Free gas	332	431	1330	2094
	Total:	1860	632	1522	**4014**
2011	Oil	1433	680	-	2113
	Dissolved gas	229	109	-	338
	Gas-condensate	78	265	-	343
	Free gas	345	1413	-	1758
	Total:	2085	2467	-	**4552**

**HC resource types are presented on «1000 m³ gas = 1 ton oil» equality basis*

3. Results and Discussions

The wide range of subcategories provided in the UNFC allows full coverage of all resource categories (C3, D1, and D2) of the AR-1984 system. The PRMS-UNFC bridge document [11] is used to convert volumes from AR-1984 to UNFC categories.

According to the PRMS classification, prospective resources are volumes of hydrocarbons estimated to be potentially recoverable from undiscovered accumulations to a given date. Potential accumulations are evaluated based on the likelihood of a geological discovery and, assuming a discovery, the estimated volumes that could be recovered through identified development projects. Prospective resources are categorized into three main groups (prospect, lead, and play).

«Prospect» (Prospective Project - an object ready for discovery) is a project associated with a potential hydrocarbon accumulation that has been adequately studied with a specific location for drilling. Project activities are aimed at assessing the likelihood of a geological discovery and, assuming a discovery, the range of potentially recoverable volumes within a commercial development program. In the AR-1984 classification, this category corresponds to C3 volumes.

A «Lead» is a potential accumulation that does not have sufficient data or estimates to be classified as a «Prospect». Additional data collection and/or evaluation is aimed at confirming the possibility of upgrading a Lead to a Prospect. This assessment considers the likelihood of a geological discovery and, assuming a successful discovery, identifies a range of potential production under realistic development scenarios. Within the AR-1984 classification, «Lead» is close to category D1.

A «Play» is a prospective series of potential structures requiring data collection and/or assessment to further analyze the likelihood of a geological discovery and, assuming discovery, the range of potential recovery under hypothetical development scenarios. Within the framework of the AR-1984 classification, Play belongs to category D2.

It should be noted that the basic principles of AR-1984 coincide with the modern Russian system of classification of reserves and resources, which was approved in 2013. The main difference is that the latter includes an economic justification of reserves. The methods and principles used to compare and harmonize the 2013 Russian system with the UNFC were also reviewed and taken into account in this work [6].

Thus, table 3 shows the relationship between AR-1984 and PRMS when describing categories of explored resources.

To compare the E-F axes of the UN Framework Classification with AR-1984 the UNFC- PRMS transition matrix is used (fig. 3).

Thus, the transition from AR-1984 to UNFC and back along the E-F axes is possible according to the following scheme (table 4).

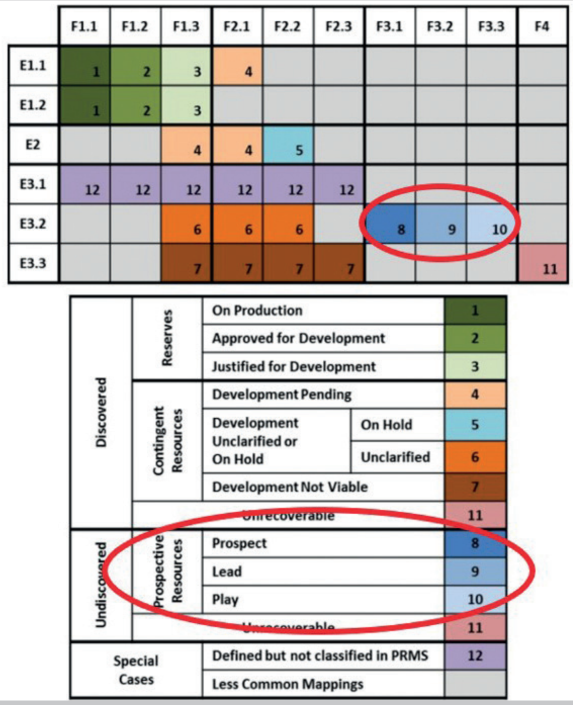

Fig. 3. The transition from the UNFC matrix to the use of PRMS

Table 3

Comparison of AR-1984 and PRMS in assessing categories of explored resources

Class/Sub-Class	Definition	PRMS	AR-1984
Undiscovered Resources	The Project, Ready to discover	Prospect	C3
	Potential accumulation, poorly defined, required more data acquisition	Lead	D1
	Prospective trend of potential prospects requires further data acquisition to define specific Leads or Prospects	Play	D2

Table 4

2-Dimensional transition from UNFC to AR-1984 (E-F axis)

AR-1984	PRMS	UNFC
C3	Prospect	E3.2 F3.1
D1	Lead	E3.2 F3.2
D2	Play	E3.2 F3.3

Table 5

Assessment of the degree of confidence in reserves and resources

AR-84	PRMS	UNFC		
		Low assessment	Best assessment	High assessment
C3	Prospect	E3.2 F3.1 G4.1	E3.2 F3.1 (G4.1+G4.2)	E3.2 F3.1 (G4.1+G4.2+G4.3)
D1	Lead	E3.2 F3.2 G4.1	E3.2 F3.2 (G4.1+G4.2)	E3.2 F3.2 (G4.1+G4.2+G4.3)
D2	Play	E3.2 F3.3 G4.1	E3.2 F3.3 (G4.1+G4.2)	E3.2 F3.3 (G4.1+G4.2+G4.3)

Table 6

Application of UNFC to the AR-1984 reserves and resources statement under the conditional «Structure C»

Year	Hydrocarbons	Exploration resources (mln.t)		
		C3 <-> E3.2 F3.1 G4	D1 <-> E3.2 F3.2 G4	D2 <-> E3.2 F3.3 G4
1984	Oil	260.8	163	11
	Dissolved gas	-	52	2
	Gas-condensate	-	105	-
	Free gas	29.4	343	14
	Total:	290.2	663	27

The incorporation of category G from the UNFC classification, which delineates the level of confidence in reserves and resources, facilitates the conclusive conversion from UNFC to AR-1984 for prospective resources.

The subcategories of the UNFC G4 category allow to classify the risks for each promising project. Finally, table 6 shows the relationship between AR-1984 and UNFC for this study.

Conclusion

- The study concludes with a comparison of the estimated resources of the AR-1984 and UNFC systems, highlighting their compatibility. Unlike the AR-1984 classification, the UNFC system takes into account existing risks and uncertainties in the assessment of non-extractable resources.
- The wide range of subcategories provided in the UNFC allows for comprehensive coverage of all resource categories (C3, D1, and D2) of the AR-1984 classification system.
- The application of the UNFC in Azerbaijan, as demonstrated in the study, will facilitate the expansion and refinement of reserve and resource reporting. It will also allow the consideration of risk, uncertainty, and geological certainty within a consistent framework.

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