International Journal of Geology, Earth & Environmental Sciences ISSN: 2277-2081
An Open Access, Online International Journal Available at http://www.cibtech.org/jgee.htm
2019 Vol. 9 (1) January-April, pp. 53-59/ Nazarov
Research Article

CREATION OF A THREE-DIMENSIONAL GEOLOGICAL MODEL OF "GAZLI" FIELD TO INCREASE THE EFFICIENCY OF THE DEVELOPMENT

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ABSTRACT
The main objective of modern hydrocarbon (HC) deposits development is to achieve the most complete extraction of their recoverable reserves at maximum economic profitability. Advanced technologies are used to achieve the highest oil recovery rate. One of the key tools is the computer 3d modeling. The purpose of this work is the structural modelling and creation of three-dimensional geological grid of the field "Gazli", lithological modelling and estimation of character of change of filtration-capacitive properties of XIII horizon Neokom+Aptsk tier. The results of petrophysical modelling, calculation of volumes of oil-saturated breeds and geological reserves of coal-mining raw materials, and preparation of hydrodynamic grid are presented. The three-dimensional geological model allowed creating a hydrodynamic model for management and optimization of the development of "Gazli" field.

Keywords: *Field, Deposit, Horizon, Modelling, Geological Grid, Geological Cube, Porosity, Permeability, Oil Saturation, Estimation of Reserves*

INTRODUCTION

Despite the rich traditions of geological science, the construction of three-dimensional (3d) digital geological models of oil and gas fields is a relatively young field in applied petroleum geology, originating and developing in about last 20-25 years (Zaloyeva *et al.*, 2008 and Gladkov *et al.*, 2012).
Currently, the main programs used in the creation of 3d geological models of oil and gas fields are DecisionSpase (Landmark), IRAP RMS (Roxar), Petrel (Schlumberger), Gocad (PARADIGM), etc.
In this paper, the IRAP RMS program of the ROXAR company was used to create a three-dimensional geological model. This product for modeling and management of field development can be applied at any stage of field development-from exploration of the area up to the last stage of time-work (Sungurov *et al.*, 2006 and Zakirov *et al.*, 2007):
1. Collection, analysis and preparation of the necessary information, data loading (import and export).
2. Correlation of reservoirs by borehole data.
3. Interpretation of data of seismic exploration (highlighting of infringements, tracing of horizons and cartography, attribute analysis, etc.).
4. Building and editing maps.
5. Construction of a model of tectonic plates.
6. Structural modeling (skeleton creation).
7. Creation of Grid (3d grid), the averaging of borehole data on the grid.
8. Fascial (lithological) modelling.
9. Petrophysical modelling.
10. Calculation of hydrocarbon reserves.
11. Well planning.
12. Analysis of uncertainties and risks.

MATERIALS AND METHODS

The purpose of the work is the structural design and creation of three-dimensional geological grid of the field "Gazli", lithological modelling and assessment of the nature of the change of filtration-capacitive properties (FCP) within the productive strata (XIII horizon of Neokom-Apts tier). The results of petrophysical modelling, calculation of volumes of oil-and-gas saturated rocks and geological reserves of hydrocarbon raw materials, and preparation of hydrodynamic grid are presented.

The structure of the Gazli field is administratively located in the territory of the Romitan District of the Republic of Uzbekistan in the north-west of the city of Bukhara, and in tectonic relation is in the Gazli rise. The accumulation of oil and gas is associated with the brachy-anticline structure, the deposit belongs to the reservoir type.

The distribution of deposits by area is controlled by tectonic peculiarities of the structure, which is also confirmed by the position of the initial elevations of the water-oil contact (WOC) (Fig. 1).

The structure was revealed in 1959. As a result of the structural drilling operations carried out. Since 1959, the field was in deep drilling and for the first time gas in the XIII Horizon was opened through well № 10, and oil through well. № 11.

The analysis of the change of the phase state of HC in the vertical section of "Gazli" shows the following pattern: From top to bottom on the incision in the upper section of the productive thickness (PT) There is a sequential change of the subsequent gas-condensate deposits: IX, X horizon Senoman tiers, XI, XI-A and XII horizons of the Albskaya Tiers, XIII-A and XIII-B Neokom+Apts tiers. The lower part of the PT is marked by the presence of low-power oil and gas-saturated tutus XIII-B, XIII-G, XIII-D Neokom + Apts tiers.

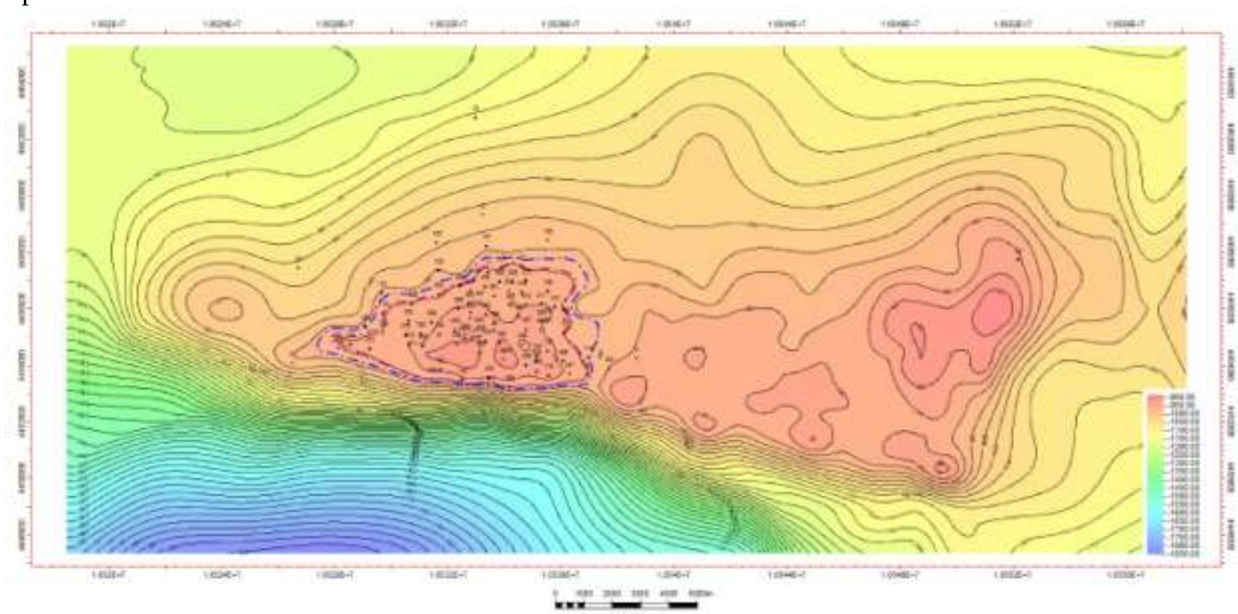

Figure 1: Sturctural map of Gazli field

In order to create a three-dimensional model of the field, the source information was loaded: the coordinates of the mouths, the altitudes, the inclinometry, the logging diagrams of 101 wells drilled in the the field of "Gazli". After loading the source data and creating a working project, a structural-stratigraphic skeleton of the model was created. For this purpose we made preliminary correlation of wells (the breakdown of seams in wells). The detailed correlation of the incision was made on the basis of a series of transverse and longitudinal profiles covering the whole structure. During the correlation procedure, the results of geophysical studies of 95 wells were used, which were subsequently introduced into the package for the creation of a static geological model. After the creation of structural-stratigraphic frame of the horizons of this reservoir, structural model of external and internal contours of the oil was built.

In studying the conditions of sediment accumulation, the principle of consistent stratigraphy was adopted, which allows to predict the order of the study of stratigraphic units, including the sequence in the process of precipitation, to make a general chronostratigraphic system of cycles in the process of formation of genetic-related layers.

RESULTS AND DISCUSSION

On the basis of sedimentation in combination with the given logging and petrophysical interpolation the collectors of XIII horizon are subdivided into 6 packs (XIII-A, XIII-B, XIII-B, XIII-G, XIII-D, XIII-E). The collectors of the XIII horizon are represented by sand bodies, which have appeared at the low level of the sea condition in the conditions of shallow-sea shoals. The total power of the horizon varies within 90-135 m. The average power of the horizon was 110 m. The sandstone horizon is changeable and increases from bottom to up. The porosity of the collector is within 18-24%. The petroleum saturated output ability of the horizon is 24-40 m. The average permeability was 0.112 m/km^2, the initial petroleum saturation was 0.62-0.71.

Within the framework of the structural-stratigraphic frame, taking into account the regularities of precipitation, a thin "cutting" of layers is performed for each stratum, thus creating a three-dimensional grid with the model of faults (3d grid). The three-dimensional grid is a cellular skeleton within which all basic stages of geological modelling occur (Fig. 2).

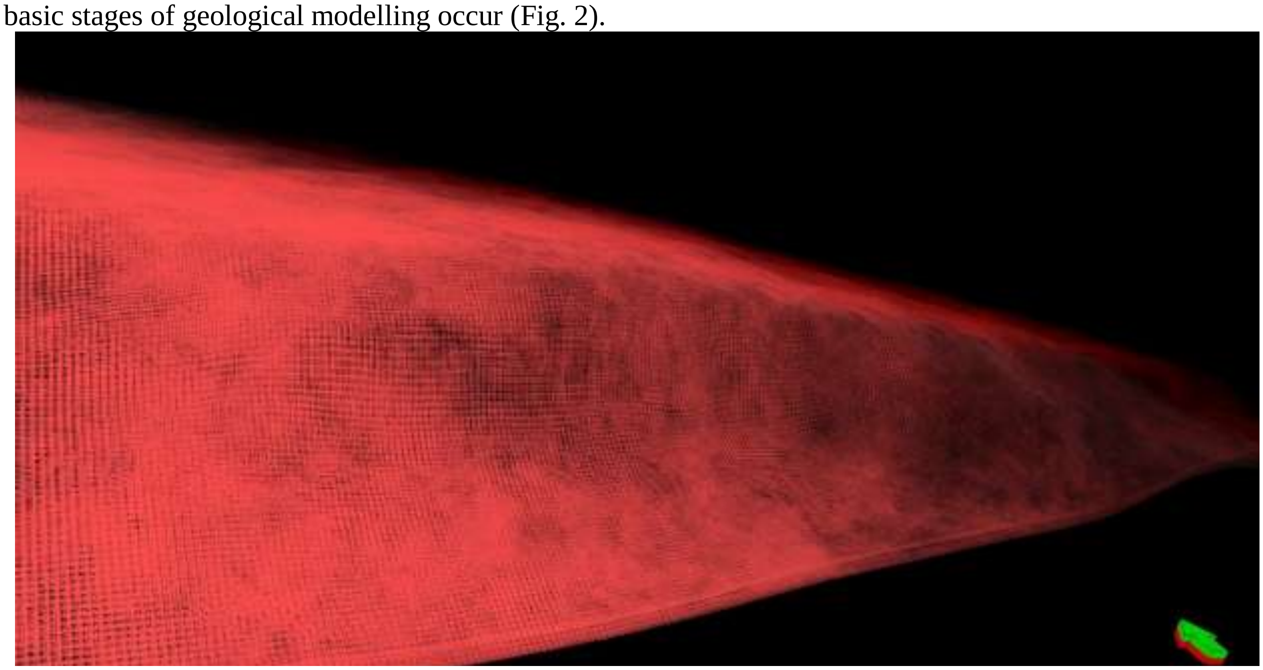

Figure 2: 3D grid of geological model of "Gazli" reservoir

The main difference of the three-dimensional grid from the two-dimensional mane is that each cell of the tri-dimensional grid occupies a certain volume in space, whereas the cell of two-dimensional mane is characterized only by the area. Correctly constructed three-dimensional grid is a basis of construction of correct geological model. After defining the structure of the 3d mesh, the mesh model cells were defined by the corner point angular point geometry. Vertical times of the model cells were chosen taking into account the differentiation of the section on FCP. The resolution of the grid vertically was determined by the number of layers, which was selected in such a way that it was most adequate to restore the field of distribution of collectors without losing sight of any prolayers. Horizontal increment of the grid was chosen taking into account the location of the square and the size of the deposit and calibrated to 100 x 100 (the grid nodes are located every 100m relative to the axes). This calibration of the grid for "Gazli" allowed to accurately build a structure, which is optimal for this grid of wells (1-2 cells between the neighboring wells) (table 1).

Table 1: 3B geological model grid parameters

Parameters	Value
Horizontal cell size	100x100
Splitting a grid vertically	Proportional
Number of layers vertically	513
Average cell thickness, m	1,64
Size of grid	396x180x513
Total number of cells	36 566 640

On the grid cells along the trajectory of wells (averaging) the results of interpretation of GIS-curves of fascia, lithology, porosity, oil saturation are carried out. The Blockwells (**Grid Block wells** (BW)) option was used to carry out the transfer (downhole data averaging) in the **Grid** container.
In order to obtain an idea of the space distribution of various lithotypes at the Gazli field and the creation of a three-dimensional parameter of lithology, after the definition of the structure of the 3d grid and the measurement of downhole data on the grid, lithological model was given (Fig. 3).

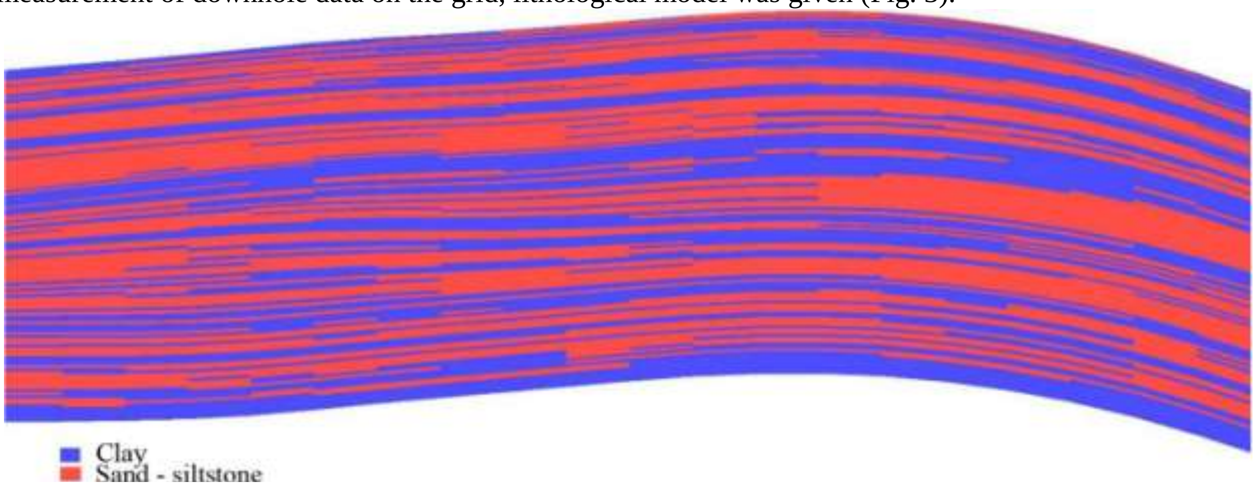

Figure 3: Distribution of lithology parameter (BW LITO)

The **RMS Indicators** module is used to create a discrete facet parameter. The advantages of the RMS Indicators module are that the indicator method allows flexible adjustment of the simulation for any type of fascia, provides a high rate of calculations at a large number of wells and the renunciation of the cut on the FCP. The resolution of the grid vertically was determined by the number of layers, which was selected in such a way that it most adequately restored the field of reservoir distribution, not losing sight of any extra layers. Horizontal increment of the grid was selected taking into account the location of the seam and the size of the deposit and caliberated to 50x50 (the grid nodes are located every 50 m relative to the axes; of this, stochastic method is most suitable for layers that have strongly heterogeneous incision of thin, poorly correlated reservoir strata). As a result of modelling, on the basis of probability of occurrence of this or that facet, each parameter cell is assigned the code (number) of the corresponding (collector or non-manifold) fascia. In addition, the most important part of the indicator simulation is the definition of variograms for each facet. Variogram analysis works better when a large number of wells are evaluated. At this stage, modelling of reservoir properties of deposits was carried out separately for each litho type of breeds (sand-alvrit and clay) that has allowed allocating clear borders at transition from one type of breeds to another.
Then the petrophysical model of oil and gas condensate of deposit "Gazli" was built, which was based on the results of the lithological modelling stage and allowed to obtain the expected three-dimensional

models of collection properties and oil and gas extraction of mountains. The **RMS Petrophysical modelling** module allows you to create three-dimensional petrophysical models that reflect:
• borehole data;
• correlation relations between parameters (porosity, oil saturation);
• spatial heterogeneity of the manifold properties;
• lithological heterogeneity of reservoir;
• geological patterns.
The built model of spatial distribution of collection properties (porosity, permeability, oil and gas saturation) is one of the key components of the computer 3d model of the oil and gas condensate field "Gazli" (Fig. 4 and 5). It is important both for the right estimation of initial geological reserves, and for reception of correct results at hydrodynamic modelling.

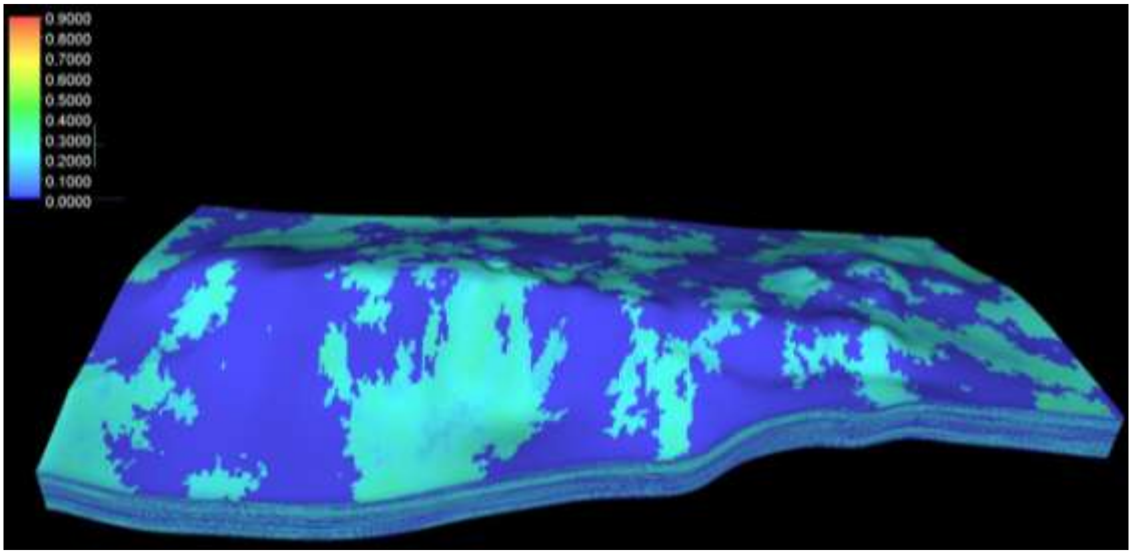

Figure 4: Porosity cube

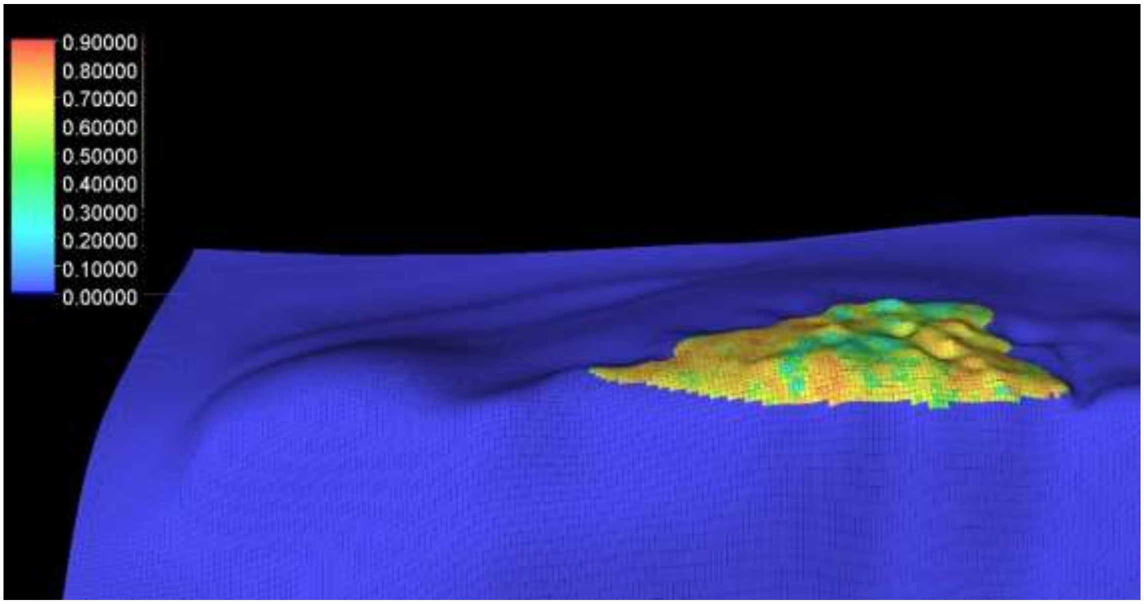

Figure 5: Saturation cube

The main result of the created 3D geological model is the calculation of the initial geological reserves of oil and gas. For oil and gas deposits in **IRAP RMS** it is possible to calculate the following types of volumes of HC **(Volumetries):**

Bulk volume-the geometrical volume of the cells lying above the WOC. Each cell in the **Bulk** parameter contains the value of the geometric volume of that cell.

Net Volume is an effective geometric volume, i.e. **Bulk volume,** but only in collectors. Calculated using **Net = Bulk x NTG (or LITO) formula.**

Pore Volume-effective pore volume-that is the volume of pore space in the collectors. Calculated using the formula **PV = Net x PORE.**

HCPV (Hydro Carbon Pore Volume)-the volume of oil (gas) in reservoir conditions. Calculated using the formula **PV X (1-Sw).**

STOIIP (Stocktank Oil Initially In Place)-the volume of oil in the surface conditions, i.e. geological reserves of oil. It is calculated by the formula **(HCPV (oil) x 1/Bo).**

GIIP (GasInitially In Place)-volume of gas in the over-the-face conditions, i.e. geological reserves of gas. It is calculated by the formula **(HCPV (gas) x 1/Bg).**

The volumetric method of calculating inventory in IRAP RMS is based on the following formula:

$Q=V_{eff\text{-}geom} \text{ x } K_{por} \text{ x } K_{petr\text{-}satur} \text{ x } K_{recalc}$

$V_{eff\text{-}geom}=S_{deposit} \text{ x } H_{eff}$

$K_{recalc} = 1/B_o$ (or B_g)

where, Q – geological reserve, m^3;

$V_{eff\text{-}geom}$ –volume of petroleum saturated layer, thousand m^3;

K_{por} – porosity coefficient, no units;

$K_{petr\text{-}satur}$ – petroleum saturation, no units;

$S_{deposit}$ – deposit area, thousands m^3;

H_{eff} – width of petroleum saturated collector, m;

B_o (or B_g) – volumetric coefficient of oil (or gas).

As a result, on the basis of the program IRAP RMS the initial geological deposits of oil and gas of the field "Gazli" on Horizon XIII were calculated.

An important circumstance, confirming the high quality of the created geological model, is the conformity of oil and gas reserves, which are in 3d geological modelling, with the reserves of oil and gas available on the balance of the government fund. When analyzing the received data it follows that the discrepancy with the reserves, on the balance of the Horizon XIII, equal to + 5.4%.

However, the main problem with the composition of project documents is the discrepancy between the static (geological) and filtration (fretting) models. Experts demand that the static and filtration models differ from each other not more than 3%.

Analysis of the obtained data shows the discrepancy of oil reserves obtained at the 3d geo-analytical modelling and the hydrodynamic grid (after the rescaling of parameters), on the Horizon XIII is-3%, which is within the limits of permissible errors.

Thus, on the basis of the most advanced scientific and technological developments in the field of geological modelling, the geological model of the XIII horizon of the Gazli field was built, which will optimize the production of deposits and significantly increase the economic effect on the extraction of residual oil and gas reserves.

Conclusion

As a result of the built model, it was possible to identify the extent of distribution by area and depth of the main collector parameters: porosity, sandstone level, oil and gas saturation, water saturation, etc.

The obtained geological model is the basis for hydro-dynamic modelling, with the help of which it is possible to implement adaptation of the model to the development history and refinement of its construction, to design the places of laying and trajectory of new wells, to produce hydrodynamic calculations and forecast of technological indicators of field development, including estimation of economic efficiency of proposed geological and technological measures, as well as duration of development of deposits.

On the basis of the built geo-analytical model the hydrodynamic model of "Gazli" was built with the help of the program NEXUS-VIP, allowing flexible management and production of the optimal variant of the deposit development.

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