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# Destruction of the Mineral Matrix and the Oil Fluid Caused by Steam Stimulation of the Oil-Containing Carbonate Rock

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## Summary

The paper presents the results of laboratory studies of the effects of steam stimulation on the oil-containing carbonate rock. Investigations were conducted on specially designed thermal setup of flow type equipped by original core holder. The influence of temperature, pressure and composition of the steam-gas eluent on the porosity and permeability of carbonate rock, the composition of the extracted oil and the efficiency of oil recovery from carbonate rock are discussed. The factors influencing on the increase of oil recovery from carbonate reservoirs were identified.

## Introduction

The world experience of exploitation of oil fields shows that at present when oil fields with heavy oils are developed the thermal methods, in particular steam stimulation, have no alternative and have a priority among other methods. The thermal methods are most relevant for development of structurally complicated carbonate reservoirs. More than 60 % of the world's oil reserves are concentrated in carbonate reservoirs. However, the recoverable reserves of these deposits reach 10-15 % only. This is due to the complexity of composition and textures of carbonate reservoirs, the high heterogeneity of their physico-chemical properties due to, in turn, a long and complex history of their formation. Difficulties in developing of carbonate reservoirs are dramatized by high density and viscosity of reservoir oils. Thermal impact on the oil reservoir reduces the effective viscosity of oil, weakens the structural-mechanical properties of the oil fluid, and increases its mobility in the filtration channels and capillary imbibition, which leads to an increase of the oil recovery factor. Thermal impact on reservoir fluid changes not only its physical properties, but also the chemical composition of the oil in result of its aquathermolysis. It is known that oil in carbonate reservoir have often the low thermal stability due to lithological properties of carbonate rocks. For the development of new more effective methods of thermal stimulation of carbonate reservoirs the systematic research of systems "carbonate rock-oil-water is needed. The model experiments with variation of temperature, pressure and composition of the injected heat carrier allow to create the scientific basis of thermal methods of development of carbonate reservoirs. The aim of the study was to identify the influence of temperature, pressure and composition of the vapour-gas eluent on the oil recovery from carbonate rock in steam stimulating.

## Theory and/or Method

The paper presents the results of laboratory tests of steam stimulation on the samples of carbonate rock. The vapour-gas impact modelling was carried out using a specially designed thermal setup of flow type equipped by original core holder. Core material was chosen from the Middle Carboniferous deposits of the Republic of Tatarstan (Russia).

## Examples

The collection of cores of carbonate rocks (after full extraction of organic matter) different by filtration properties was investigated in varying the composition of the eluent (steam - air - nitrogen) and temperature (250 - 400 °C). The "low temperature" dissociation of carbonate rocks initiated by steam was determined (Fig. 1). The amount of the gaseous products of thermolysis released in terms of change of oxygen concentration in reactor environment was determined by means of gas chromatography (Fig.2).

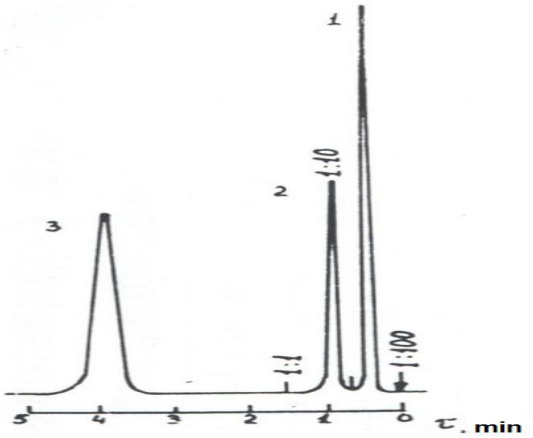


Fig. 1 – A typical chromatogram of gas releasing from carbonate rock at 350 $^{o}$C:

1 – air, 2 – carbon dioxide, 3 – water

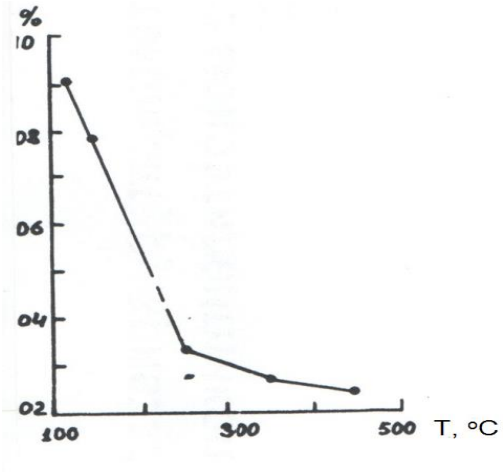


Fig. 2 – The oxygen content in reactor gas environment during the thermolysis of carbonate sample

Using a mixture of steam and nitrogen as eluent, the increase of the rock permeability for gas (almost 1.5 times) was detected, which was due to opening of dead-end pores and growth of network of microcracks. It is shown that the carbonate rock of average porosity (12%) at 400 °C in a vapour-gas eluent under atmospheric pressure produces carbon dioxide, the amount of which is enough for a 60-fold purge of its pore volume. It was found that at 400 ° C and under pressure of vapour-gas mixture of 120 atm 74% of the total amount of the oil fluid is removed from core material that constitutes 90% of the amount of oil fluid extracted by organic solvents. It was established that steam stimulation at temperatures up to 500 ° C under a pressure 40 atm in the condensation zone is not accompanied by degradation of oil components; the chemical composition of oil condensate is similar to the composition of the original oil according to spectral analysis and gas chromatography (Fig. 3).

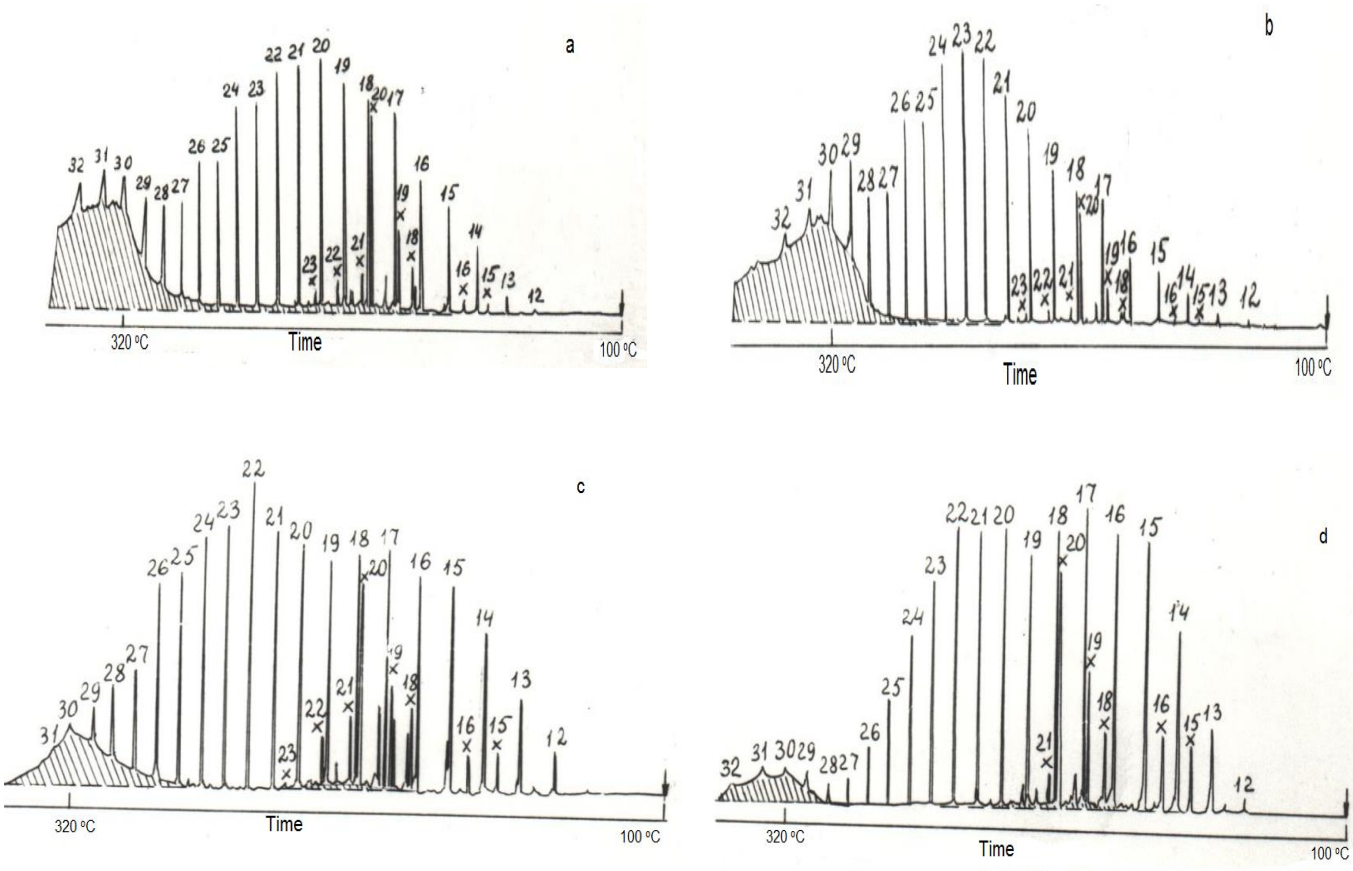


Fig.3. Gas chromatograms of oils extracted from samples of carbonate rocks: 1 - extracted oil, 2, 3, 4 – condensates of steam displacement of oil at 500, 400 and 300 °C, respectively.

## Conclusions

Three interrelated factors of enhanced oil recovery from low permeability carbonate reservoirs were experimentally identified: the increase in duration of steam stimulation, rate of steam eluent flow, and temperature. The most economical and sustainable option of steam stimulation of oil saturated carbonate reservoirs was proposed.

## Acknowledgements

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