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## Optimizing Well Productivity by Controlling Acid Dissolution Pattern During Matrix Acidizing of Carbonate Reservoirs

F. F. Chang, SPE and M. Abbad, Schlumberger

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### Abstract

The chemical nature of carbonate rocks makes acidizing an effective matrix stimulation technique. Acid dissolves carbonates at high reaction rate to create flow channels ("wormholes"). The high reaction rate often needs to be reduced to allow wormholes to penetrate deep into the reservoir hence extending the effective wellbore drainage radius.

The wormholes created by a retarded acid are deep but thin. During production, the flux through the thin wormholes can be so high that high pressure gradient occurs. Therefore the optimized wormhole geometry should be functions of reservoir properties such as permeability and pressure as well as fluid types such as oil or gas. To generate wormholes of various diameters and penetration depths, different acid types and volumes have to be used.

Acidizing for optimized productivity requires first determining what is desired wormhole pattern. Currently, the numerical models focus on computer rendered wormholing pattern by pre-selected acid formulation and volume from past experiences and cost consideration. However, it is important to first rationalize the targeted productivity from the specific reservoir have specific properties such as permeability and pressure, then to determine the wormhole pattern required to achieve the well deliverability. Finally, the acid formulation and volume can be determined to generate the desired wormhole pattern.

The discussion in this paper takes a first step toward the goal of designing matrix acidizing jobs in carbonates for delivering targeted productivity. Using a mathematical model, a sensitivity analysis is conducted to determine the preferred dissolution patterns for different formation permeability and pressure. It examines the conventional matrix acidizing practices and provides an idea on how the treatment design can be improved.

### Introduction

Acidizing oil and gas wells has frequently been viewed as art than science. Many laboratory researches have been conducted trying to expand and enhance the knowledge of carbonate matrix acidization. Plenty of mathematical modeling efforts are intended to bridge the gap between the laboratory scale studies and the field implementation. However, crossing from research to the field applications is still dominated by experience, rules of thumb, and conservatively copying previous successes in the geographical vicinity.<sup>1,2</sup> In sandstone acidizing, the acid-rock reaction chemistry is extremely complex.<sup>3,4</sup> Nonetheless, the dissolution reactions of sandstone constituents are slow and generally considered surface limited, they are not affected by the acid injection rate. The materials dissolved by acids are typically the pore lining or filling materials rather than the matrix framework itself. Hence the framework of the sandstone is not significantly altered by the acidizing process. Since the matrix structure is generally intact, the entire physical and chemical processes can be modeled by basic fluid flow in porous media coupled with thermodynamic equilibrium among the reactants and products. For practical purposes, the models can be used to design field scale acid stimulation treatment and to predict the performance of the stimulated wells. For carbonate acidizing on the other hand, the chemistry of acid-carbonate dissolution is straight forward, especially for the HCl-carbonate reactions. The acid dissociates into hydrogen and its conjugate base ions. The hydrogen ions attack the carbonate to generate  $\text{Ca}^{2+}$ ,  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . Equation 1 shows acid dissolution of limestone.

