

## 2005 INTERNATIONAL SYMPOSIUM ON THE HISTORY OF THE OIL INDUSTRY

### ABSTRACTS

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#### A HISTORY OF PRODUCED SALTWATER DISPOSAL IN U. S. GULF COAST PETROLEUM FIELDS, 1901—1970

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With the discovery of petroleum at Beaumont, TX, and Jennings, LA, in 1901, the U. S. Gulf Coast soon became one of the world's great production regions. The fields also produced unwanted saltwater, a problem that compounded over time. Early on, oil was inadequately separated from water, and the oily water was disposed onto the ground and into local drainage systems. While oil/water separation technology rapidly improved, the inadequate disposal of increasing saltwater volumes and the associated litigation resulted in producers modifying their disposal practices. By 1908, lawsuits from TX and LA coastal rice farmers resulted in the practice of storing saltwater in earthen pits from May until September while rice farmers used the streams for water irrigation. The produced waters were released during the rainy season, and the dilution decreased the associated damage. Other methods used early on included seepage and evaporation pits, purchase of drainage easements which fed into larger streams, saltwater disposal pipelines to coastal water bodies, and saltwater re-injection. Seepage and evaporation pits were commonly used in LA and TX through the 1960s to decrease visible surface damage, but much of the disposal was by seepage rather than evaporation. Pits were more difficult to use in the Gulf region, especially coastal areas, due to high rainfall, low evaporation, shallow water tables, and slow infiltration in clay-rich soils. Subsurface injection was more costly, but was used in several large fields by the 1930s. Major studies on production water pollution were conducted in the 1940s, 1950s, and early 1960s by different agencies. The growing recognition of the damage to freshwater resources resulted in the beginning of significant regulatory control on produced waters in the 1960s.

#### OIL AND THE GREEK FIRE

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During the Seventh Century, warfare took a terrible leap in destructive power by the use of what has become known as *Greek Fire*, although the people who invented it considered

themselves to be Roman, not Greek, and the material was known by many names, *e.g.*, liquid fire, artificial fire, Median fire, etc. The name was coined by the Crusaders, the first Europeans on whom the weapon was used. According to several authors, the date, at least within a few years, of the invention of Greek Fire is well known. Leo Tacticus writing in the Eighth and Ninth Centuries A.D., and Theophanes, in his *Chronographia*, written between 811 and 815 A.D., described continual attacks by Arabs on Byzantium between 671 and 678 A.D.<sup>1</sup> The Arabs were eventually forced to withdraw after being defeated by a new chemical-type weapon, called *marine fire*, invented only a few years earlier by Callinicus (Kallinikos), an architect-engineer from Heliopolis<sup>2</sup> who had taken sides with the *Romans* of Byzantium. But if Callinicus had come from Syria with the invention, then it should have been used by the Arabs as well, thus it seems that Greek Fire was invented by Byzantine chemists working in the capital, Constantinople, and not by the Greeks. Others feel that Callinicus simply perfected his idea after arriving in Constantinople, and it is known he was producing light fractions from petroleum by distillation at Byzantium about 670 A.D. As early as 100 A.D. in the Near East, Alexandria and Syria, a distillation process was operating in which the vapor was cooled with air or sponges. There is evidence that the Arabs were using a form of Greek Fire perhaps before the Battle at Cyzicus (673), but certainly they used it in the siege of Heraclea in Cilicia in 807. Thus, the distillation process was not new, but the use to which the product was put was changing. Regardless of the true source of the first formula, in their battle against the Arabs in the late Seventh or early Eighth Centuries A.D., the Byzantine ships all were carrying *syphons* or what today would be called *flame-throwers* which could launch flaming material on to their enemy's ships and troops. In 941 A.D. a small squadron of 16 Byzantine ships with *syphons* on their sides and the new Greek Fire, defeated a Russian fleet of 1,000 ships under the command of Prince Igor. Thus the use of petroleum products in warfare is not a recent invention.

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1 Other scholars indicate that the battles lasted until 715 (Partington, 1960), but Forbes (1959) gives the date as 673 A. D. for the battle of Cyzicus. Leo III used the same weapon when he attacked the Arab fleet in 717.

2 According to Needham et al. (1986) it is not known, for certain, which Heliopolis, in Syria or in Egypt, but Partington (1960) says it is the one in Syria.