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硫酸盐热化学还原作用对原油裂解成气和碳酸盐岩储层改造的影响及作用机制

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摘要:

硫酸盐热化学还原作用(Thermochemical sulfate reduction, TSR)是发生在油气藏中复杂的有机-无机相互作用,它不仅会引起含 $H_2S$ 天然气的富集,其产生的酸性气体对碳酸盐岩储层还具有明显的溶蚀改造作用。本文基于黄金管热模拟实验,研究了TSR反应对原油裂解气的生成的影响,发现这种氧化还原反应的存在能明显降低原油的稳定性,促进具高干燥系数的含 $H_2S$ 天然气的生成。结合原位激光拉曼实验结果,证实了实际油藏中启动TSR反应的最可行的氧化剂应该是硫酸盐接触离子对(CIP)。全面探讨了影响TSR反应的地质和地球化学因素,提出除了初始原油的组分特征、不稳定含硫化合物(LSC)的含量外,地层水的含盐类型及盐度同样是控制TSR反应的关键因素。同时,基于大量地质分析,发现TSR对碳酸盐岩储层具有明显的溶蚀改造作用。结合溶蚀模拟实验,提出了酸性流体对碳酸盐储层溶蚀改造的机制,且深层碳酸盐岩层存在一个由TSR作用形成的次生孔隙发育带。研究认为,烃类与硫酸盐矿物的氧化还原反应与其产物对碳酸盐岩储层的改造是TSR作用的两个不可分割的部分,它们相互依存和制约。

英文摘要:

Thermochemical sulfate reduction (TSR), which is a complex organic-inorganic interaction in reservoirs, can not only generate  $H_2S$ -bearing gas but also reform reservoirs by its sour gas products. This paper firstly studied the influence of TSR on the occurrence of oil-cracking gas by gold-tube pyrolysis. It was revealed that the redox reaction can evidently decrease the thermal stability of oil and accelerate the generation of natural gas with  $H_2S$  and high dryness. It was confirmed that contact ion pairs (CIP) should be the most feasible oxidant in initiation reaction of TSR collectively by in situ Raman technology and pyrolysis experiments. The potential factors, which can dominate TSR reaction, were thoroughly discussed. It was found that the salts type and concentration in addition to oil compositions, labile organo sulfur compounds (LSC) content should be the critical factors for occurrence of TSR. On the other hand, TSR was demonstrated to play an important role in the reformation of carbonate reservoirs on the basis of detailed geological observations. The corrosion mechanism by sour fluid was also revealed with the assistance of corrosion model experiments. Moreover, there was a secondary porosity zone formed by TSR in deep carbonate reservoirs. It is suggested that, the redox reaction involving hydrocarbons and sulfate and the reformation of reservoir should be two closely related and dependent processes induced by whole TSR.

关键词: [TSR](#) [反应机制](#) [接触离子对](#) [碳酸盐岩储层溶蚀](#) [有机-无机相互作用](#) [四川盆地](#)

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