Using Envisat InSAR time-series to investigate the surface kinematics of an active salt extrusion near Qum, Iran

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A B S T R A C T
Lower Oligocene-Miocene rock salt is exposed in several diapirs in the central plateau of Iran along the northern margin of the Great Kavir basin. These include a small but mature salt extrusion known as Qum Kuh located near the city of Qum. We use small-baseline interferograms to study the surface displacements of Qum Kuh. The interferometric dataset consisted of 149 interferometric displacement maps derived from 35 C-band ASAR images collected by Envisat satellite in both ascending and descending orbits from 2003 through 2009. The results of the displacement time series analyses show significant long-term trend of horizontal motion toward gentle slopes of Qum Kuh, punctuated by seasonal variations during dry and wet seasons. Interferometric Synthetic Aperture Radar (InSAR) time series results suggest that the salt near the spreading center, where the salt first surfaces from depth, is extruded to the more gentle flanks of Qum Kuh and that down-slope gravitational spreading of the extruded salt accelerates when it is wet.

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1. Introduction
Salt layers underlying a thick sedimentary overburden can start to flow during basin extensional subsidence, giving rise to the development of a variety of halokinetic structures, such as salt pillows, salt walls and salt diapirs (Krzywiec and Weinberger, 2006). Studying salt rheology and the dynamics of extrusive salt structures has great potential to provide valuable information for engineering and scientific purposes, such as the storage of natural gas and hazardous waste (Allen, 1972). Scientists have traditionally used different classical surveying approaches to measure the rate of salt flow to enhance their knowledge of the active or inactive states of salt domes (Trusheim, 1960; Szczeprowski, 2004).
The salt diapirs emergent in different parts of the Iranian continental plateau, e.g., the Zagros fold-thrust belt and the Central Iran block, can be considered excellent examples of salt extrusions. These structures have been subject to numerous studies. Talbot and Rogers (1980) monitored the daily and seasonal movements of a salt diapir in the Zagros Mountains using glaciological techniques (Talbot and Rogers, 1980). The extrusion and dissolution rates of the Hormoz salt have been investigated by analytical (Wenkert, 1979; Talbot and Jarvis, 1984) and numerical modeling (Talbot et al., 2009). The vertical movements and apparent horizontal displacements of the salt extrusion at Kuh-e-Jahani, Iran, was investigated using 43 markers dispersed over this mountain of salt for 4.5 years, and the results were used to calibrate a simple numerical model (Talbot et al., 2000). The geology and models of salt extrusion at Qum Kuh near the city of Qum was investigated by (Talbot and Afzali, 2004). Schleider and Urai (2007) investigated the microfabrics and microstructural processes affecting extrusive strains of Eocene-Oligocene rock salts from the Garmgarh hills and the Eyankeye plateau in central Iran. Talbot and Pohjola (2009) investigated subaerial salt extrusions in Iran as analogs of ice sheets, streams and glaciers and found that both glaciers and namakiers surge, but the association between surges and changes in boundary conditions are much clearer for namakiers than for glaciers (Talbot and Pohjola, 2009). A few Synthetic Aperture Radar (SAR) interferograms from 2003–2006 showed that the Garmgarh salt nappes are not active (Balkoupor and Talbot, 2012). Cosgrove et al. (2009) attributed the kink folds in the surficial salt of Qum Kuh to lateral