Salt welds form due to salt expulsion and thinning by mechanical (e.g. salt flow) and/or chemical (e.g. salt dissolution) processes. Welds can play a major role in the hydrocarbon potential of any salt basin. For example, a complete weld can create a pathway for hydrocarbon migration, whereas an incomplete weld can create a barrier that can act as a seal to trap hydrocarbons. Despite being ubiquitous in salt-bearing sedimentary basins, little is published on weld thickness and composition, and it is uncertain whether it is possible to determine these properties using seismic data alone, before drilling. In this talk we use 3D seismic reflection and borehole data from the Santos Basin, offshore Brazil and the northern Gulf of Mexico to characterise the geology and geophysics of salt welds, and how their lithological properties may vary as a function of their position within a salt-tectonic system.

Data from the Santos Basin allow us to characterise the geological and geophysical expression of a primary weld associated with the flow of Aptian salt. Seismic data suggest that, locally, presalt and postsalt rocks are in contact at the base of an Upper Cretaceous minibasin, implying that several apparent welds, separated by low-relief salt pillows, are present (see left). However, borehole data indicate that 22 m of anhydrite, carbonate and sandstone are present in one of the welds, indicating that this and other welds may be incomplete (see below). This observation, combined with data from offset wells, suggest that salt-thinning involved preferential expulsion of the more mobile, lower viscosity halite and potash salt material from the autochthonous layer. Because of this, the apparent weld is volumetrically enriched in non-evaporite lithologies and relatively viscous evaporite lithologies (anhydrite).

Data from the northern Gulf of Mexico allow us to investigate the thickness and composition of a tertiary salt weld, located at higher structural levels in a salt-tectonic system. Seismic data image an apparent weld at the base of a Plio-Pleistocene minibasin that subsided into allochthonous salt (see below-left). Borehole data indicate the weld is actually incomplete, being c. 24 m thick, and containing an upper 5 m thick halite and a lower 15 m thick halite, separated by a 4 m thick mudstone (see below-right). The age and origin of the intra-weld mudstone is unclear, although we speculate it is either: (i) Late Jurassic, representing material transported upwards from the autochthonous level within a feeder, and subsequently trapped as allochthonous salt thinned and welded, or, perhaps more likely; (ii) Pliocene, representing a piece of salt carapace reworked from the top of and eventually trapped in, the now locally welded sheet.
The final dataset is also located in the northern Gulf of Mexico. Here we investigate a tertiary weld that is located at the base of a minibasin carried basinward on top of an allochthonous salt canopy. Intraminibasin thrusts suggest the depocentre was shortened during welding, and that the weld itself may have been sheared, a process that could, conceptually at least, lead to complete welding. However, borehole data reveal the weld is incomplete and contains c. 38 m of pure halite.

Our three case studies show that even high-quality 3D seismic reflection data may be unable to discriminate between a complete and incomplete weld; we suggest that, during the subsurface analysis of welds, the term ‘apparent weld’ is used until borehole data unequivocally proves the absence of salt. The presence of relatively thin, remnant salt within welds at relatively shallow and deep levels of salt;tectonic systems lends support to models of welding based on viscous flow. The halite-rich character of the tertiary weld vs. the halite-poor character of the primary weld also supports the hypothesis that tectonic purification may occur during salt flow.