**Document-S1:** **Summary of previous literatures on mechanical compaction**

In the past, several studies were carried out to understand the evolution of microfabrics due to the mechanical compaction of mudstone and shale. These studies can be broadly classified into two categories- 1) studies based on laboratory experiments; ([Mitchell, 1956](https://www.sciencedirect.com/science/article/pii/S0264817209001743?casa_token=YRPYu9fDnPIAAAAA:yPM4u0Cji4IJPzDBPFSkGy4ufXZbbdPAvRKgS8uLYD7uo_LwDK720wQ0SHH9EbDLiwhu4Viq3A" \l "bib25); Bowles, 1969; Griffiths and Joshi, 1989; 1990; Vasseur et al. 1995; Djeran-Maigre et al. 1998; Cetin, 2004; Mondol et al. 2007; Fawad et al. 2010; Day- Stirrat et al., 2011; Emmanel and Day-Stirrat, 2012), and 2) studies on natural samples (Meade, 1964; Oertel and Curtis, 1972; Sintubin, 1994; Ho et al., 1999; Aplin et al. 2003, 2006; Desbois et al. 2009; Milliken and Reed, 2010; Day-Stirrat et al., 2008; 2010; 2012).

**Experimental studies-**

Mitchell, (1956) experimentally showed that brine saturated randomly oriented Illite-Quartz mixture converts to a preferably oriented fabric due to a small increase in compressive stress, and the fabric tends to align perpendicular to the applied stress field. However, similar experiments with montmorillonite did not show a very consistent result (Mitchell, 1956). Bowles et al., (1969) collected core samples from the Gulf of Mexico and performed compaction experiments on fine-grained sediments. Further, the progressive change of the microstructure was documented using an electron microscope. It was observed that at very low stress of 0.4 MPa the sediment shows the random orientation of the particles although the sample appears to be densely packed. While the same sample was subjected to a compressive stress of 6.3MPa the microstructure showed the preferred alignment of particles (Bowles et al., 1969). Griffiths and Joshi, (1989) studied change in pore size distribution during consolidation of clay, and observed reduction in total volume is largely related to the reduction in largest existing pores. With increasing consolidation stress, pore size distribution curve shifted toward smaller pore sizes. Griffiths and Joshi, (1990) studied change in pore distribution due to secondary consolidation using mercury intrusion porosimetry. The maximum effect of secondary compression was observed in the pore size range of 100 to 1000nm which is inconsistent with micropore deformation theories. Using scanning electron microscopy and mercury intrusion porosimetry, Delage and Lefebvre, 1884 studied structures of intact, remolded and oven-dried soil, and evolution of soil structures during 1-D consolidation. They observed, initially at the beginning of consolidation, largest interaggregate pores first get affected, and with an increase in consolidation, smaller and smaller pores get affected. Vasseur et al., 1995 performed compaction experiments on clay in the load range between 0.1MPa to 50MPa corresponding to a burial depth of several kilometers and studied the microstructure using TEM (transmission electron microscopy). This study revealed that the void ratio in the mudstone sample decreases due to particle reorientation and the degree of anisotropy of the particle alignment is a function of applied compressive stress. Djeran-Maigre et al. 1998 performed compaction experiments on kaolinite, illite, and illite-smectite mixed clay, and revealed that an increase in compaction stress caused reorientation of the particles perpendicular to the loading axis without deforming any particle structure. Cetin, (2004) examined the change in void ratio with the change in orientation of pores in an artificial soil with increasing compressive stress. The author observed that the orientation of the pores does not significantly change while the stress is below the consolidation load, and with increasing compaction stress above consolidation load the preferred orientation of the pores significantly increases. Mondol et al., (2007) performed experiments to understand the compaction behavior of dry and brine saturated clay aggregate ranging from smectite to kaolinite composition. They observed that kaolinitic clay compacts more than the smectite clay, and brine saturated clay is more compressible than dry clay. The greater degree of compaction of kaolinitic clay than the smectite clay was explained by the difference in grain sizes, as kaolinitic clay has much larger grains compare to smectite clay. Fawad et al., 2010 performed mechanical compaction tests on brine saturated synthetic silt and clay mixture and examined the changes in microfabric as a function of effective stress. They observed that clay-rich samples show the maximum initial porosity compare to silt-rich samples, and with increasing compressive stress clay-rich samples compacted to a greater degree. The degree of alignment of particles was a function of the clay fraction in the sample. Due to applied stress, mica/illite particles showed a comparatively greater degree of alignment compared to kaolinite because mica/illite particles exhibit a greater aspect ratio. Schneider et al., (2011) studied the evolution of porosity and permeability during compaction experiments on resedimented Boston Blue clay. After the experiments, they analyzed the microstructure of the samples using SEM and mentioned that the samples enriched in silt content show relatively greater porosity as larger pores are always found to be associated with the silt particle aggregate. They stated that the increase in silt content redistributes the force chain associated with the compaction load which ultimately preserves large pores during loading. Due to greater porosity, the samples enriched in silt content also show greater permeability. Recently Day-Stirrat et al., (2011) performed experimental studies on Boston Blue clay to understand the effect of vertical effective stress and composition. They stated that an increase in silt content can significantly reduce phyllosilicate fabric strength at a particular vertical stress. Moreover, the presence of silt content has a profound effect on the phyllosilicate fabric strength compare to the effective stress alone. Emmanuel and Day-Stirrat, (2012) also performed compaction experiments on resedimented Boston Blue clay and studied the mechanism associated with a reduction in pores due to compaction strain. Finally, based on their results they interpreted that the pore deformation depends on the sizes; larger pores deform faster compare to smaller pores in the sample due to compaction strain.

**Studies on in situ compaction of natural clay-**

Meade, (1964) studied natural mudstone samples and mentioned that the rearrangement of particles during compaction is a complex process that depends on several factors such as particle size, clay-mineral types, the composition of fluid, temperature, effective stress and initial arrangement of particles, etc. Oertel and Curtis, (1972) studied Upper Carboniferous shale in quarries near Penistone, England, and further estimated compaction strain using both the porosity and fabric of the same samples. They used the X-Ray diffraction technique to quantify the preferred orientation of particles from the samples and further estimated compaction strain considering the March model (March, 1932). It was observed, there is a systematic difference between the compaction strain estimated using porosity and fabrics. Compaction strain estimated from the fabric was always smaller compare to the compaction strain estimated using porosity. It was concluded that the systematic difference in the result could be because of the underestimation of the degree of preferred orientation of platy particles, or maybe due to systematic underestimation of large strains by the March model. By studying fabrics of natural mudstone using X-Ray pole figure goniometry, Sintubin, (1994) found that illite clay fabric was systematically more preferably oriented compare to chlorite/kaolinite fabric. However, this study did not mention the influence of grain size and organic matter on fabric development. Ho et al., (1999) studied the microstructure of mudstone samples from the shallow-water Gulf of Mexico using X-Ray goniometry and transmission electron microscopy (TEM) to understand the preferred orientation of Illite –Smectite (I-S). No significant preferred orientation was observed in shallow pre-transition samples for smectite-rich I-S, and the development of weak preferred orientation for Illite-Smectite (I-S) was first detected at the depth slightly less than smectite to illite (S-I) transition. Aplin et al., (2003) analyzed deepwater Gulf of Mexico mudstone using X-Ray texture Goniometry and found very little platy mineral realignment even at the burial depth of 6000 m. Worden et al., (2005) studied Cretaceous mudstone from the North Sea using back-scattered electron micrographs and observed isotropic clay fabric at the shallower depth samples. However, at a greater depth of around 3300m, they observed the preferred orientation of clay fabric. They further explained that the preferred orientation of clay fabric developed due to smectite to illite transformation. Aplin et al., (2006) examined the fabric of the Miocene-Pliocene mudstone samples from 1.8 km to 5.8 km of the deepwater Gulf of Mexico using X-Ray texture goniometry. It was observed that intense mechanical compaction up to 5.8 km depth has not resulted in strongly aligned phyllosilicate fabric. Day-Stirrat et al., (2008) studied mudstone core samples from the Podhale basin and quantified the variation in phyllosilicate fabric alignment using a high-resolution X-ray texture goniometer (HRXTG). They observed that the reduction in porosity up to ~10% corresponding to a burial depth of 2.4 km, resulted in only moderately aligned phyllosilicate fabric. The coarser-grained mica and chlorite grains were found to be strongly aligned parallel to the bedding planes which were interpreted to be deposited as a single grain rather than isotropic flocs. Day-Stirrat et al., (2010) studied diagenetically altered mudstone samples collected from the deep Texas Gulf Coast and Northern North Sea. They further stated that the total clay content and fabric intensity are positively correlated; whereas quartz content and fabric intensity are negatively correlated. Day-Stirrat et al., (2012) studied the microstructure of the core samples collected during IODP Ocean drilling program from Ursa Basin, Gulf of Mexico using SEM imaging on Argon ion beam polished surface and X-Ray Goniometry. They observed that the mudstone samples with consistent composition and the grain size decrease porosity 80% to 37% from sea-floor to 600 mbsf depth. An increase in effective stress caused preferential loss of larger pores, and as a result, the mean porosity of the samples decreased. Due to an increase in burial depth, only a small increase in clay mineral fabric intensity was recorded in the samples.

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