

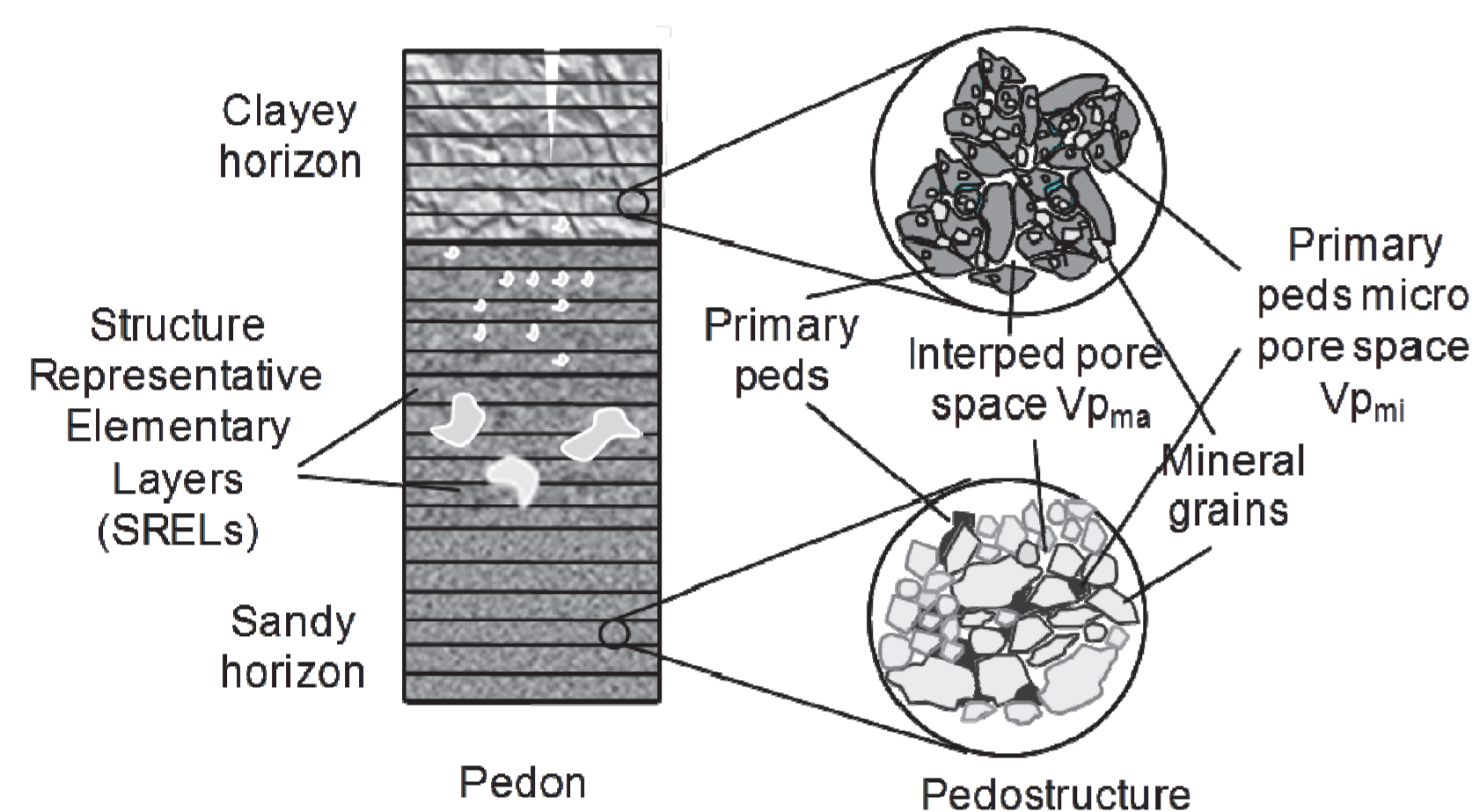
# Hydro-Structural Characterization of Soil Medium – TypoSoil™ Apparatus

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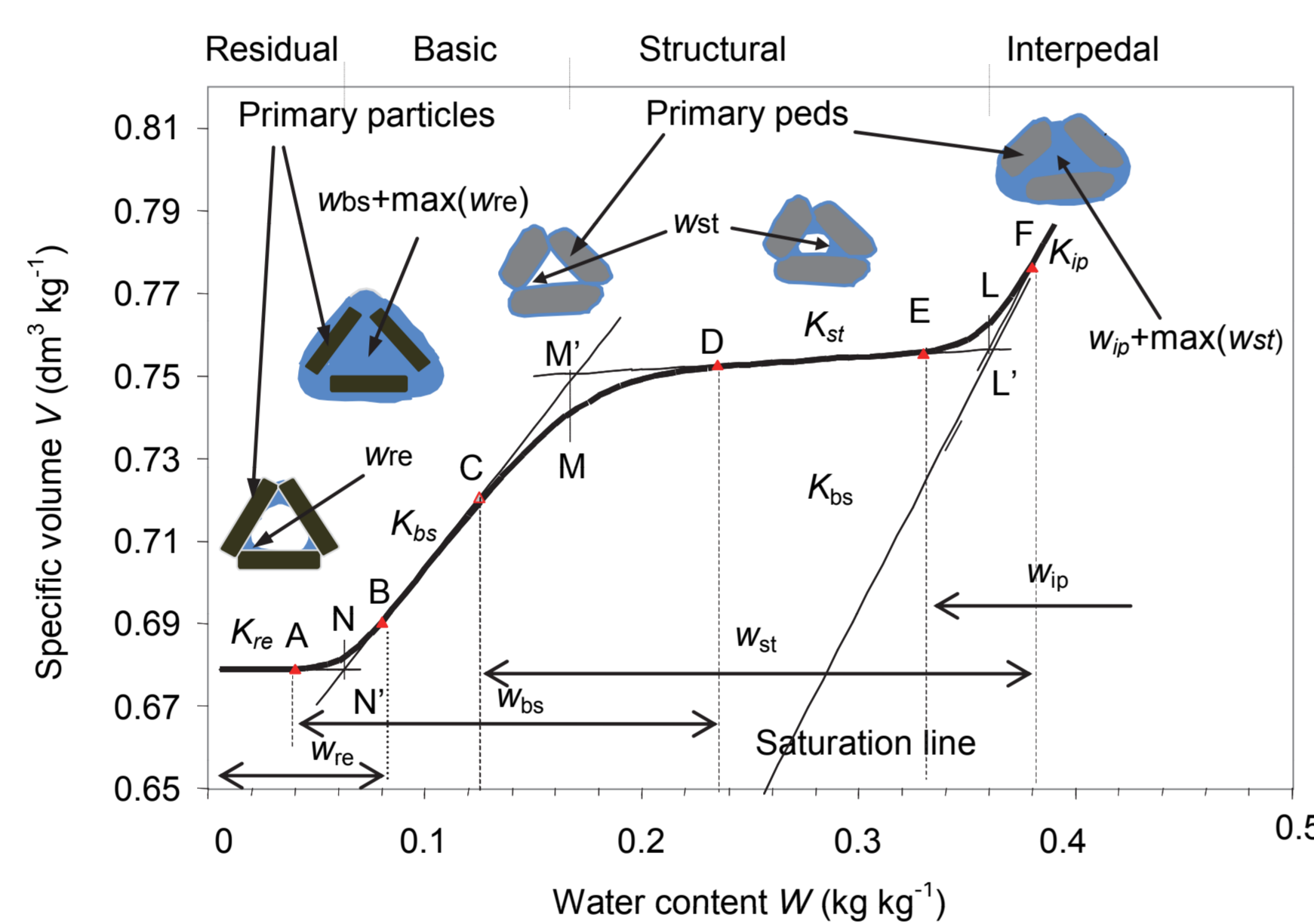
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## INTRODUCTION

TypoSoil™ is a new device for characterizing the hydrostructural properties of the soil medium organization. It measures simultaneously and continuously three state variables: the soil water content, the soil volume and the soil water potential. From these state variables, the values and shapes of the two fundamental characteristic curves: soil shrinkage curve  $[V(W)]$  and the water potential curve  $[h(W)]$  can be produced. These curves form the thermodynamic state equations of the soil medium's hydrostructural equilibrium. Other measuring methods are time consuming and provide limited data, failing to accurately depict these curves. The automated TypoSoil™ measurements were used to model hydrostructural behavior under the thermodynamic theory of the soil medium to obtain physically based parameters. In this study, the apparatus was used to measure both curves of reconstituted and undisturbed soil cores of two native soils of Qatar from saturation to dry state by evaporation. The measurements validate this procedure for the soil sample preparation and provide consistent measurement.



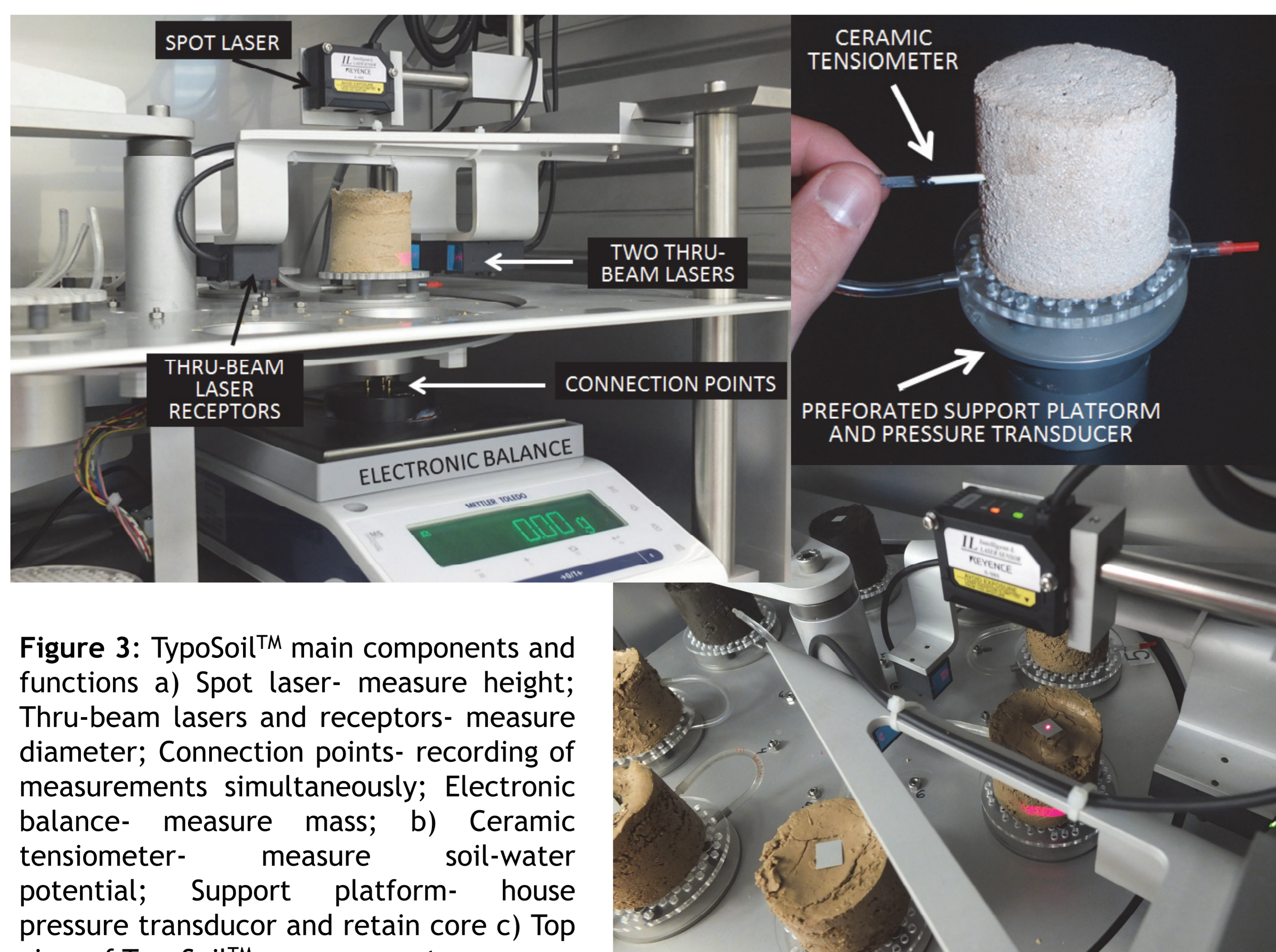
**Figure 1:** Representation of internal organization of pedon, hierarchized into its hydro-functional levels of organization [from Braudeau et al. 2009].



**Figure 2:** Various configurations of air and water partitioning into the two pore systems, inter- and intra- primary peds, related to a standard shrinkage curve [from Braudeau et al. 2004].

## OBJECTIVES

- Introduce a new physical characterization approach based the thermodynamic theory of the soil medium (Braudeau et al. 2014).
- Validate a methodology for preparing reconstituted and undisturbed soil samples for apparatus' measurements that are consistent.
- Evaluate the efficiency of this kind of characterization where each parameter has a physical meaning and quantifies a specific hydrostructural property of the Podostructure.



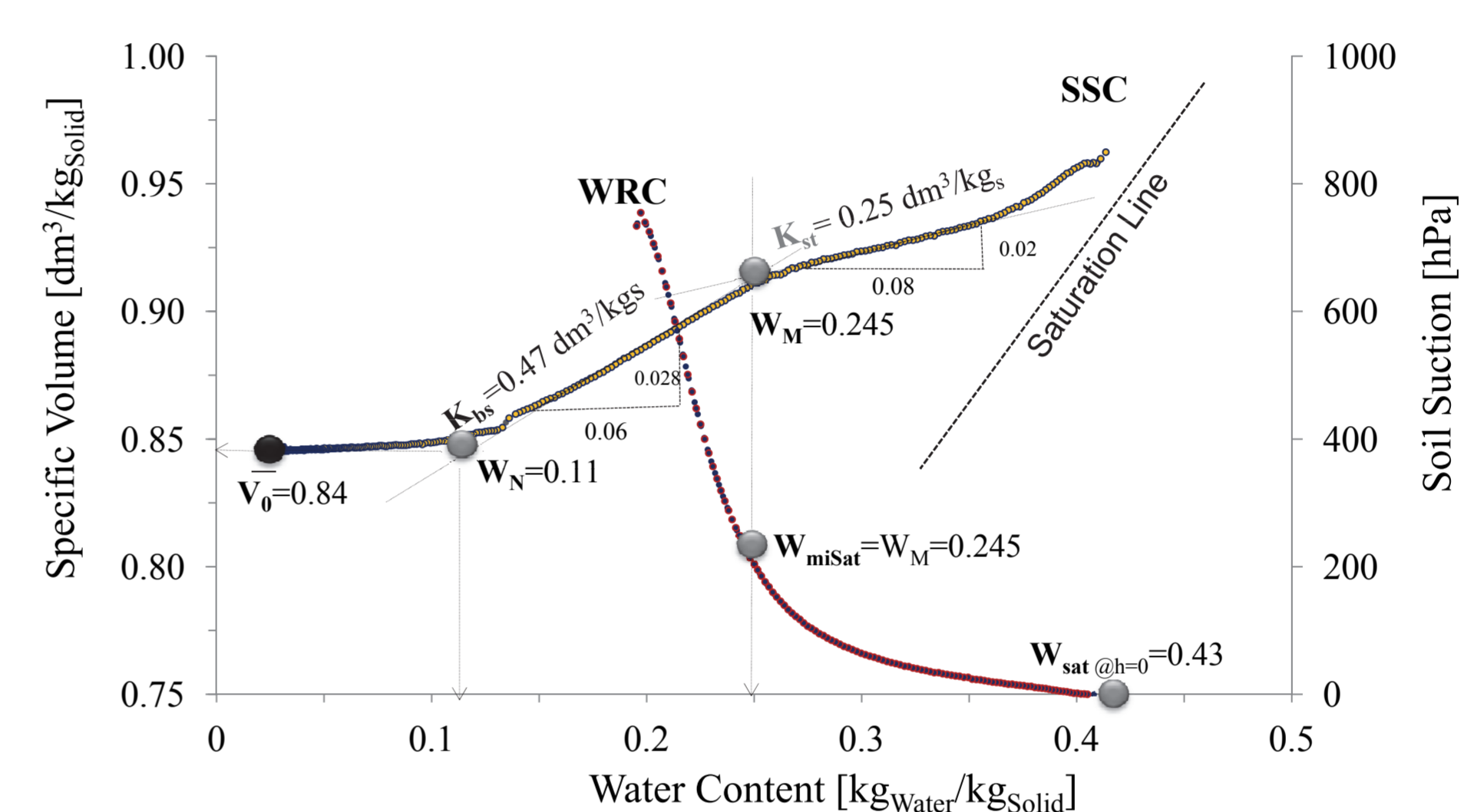
**Figure 3:** TypoSoil™ main components and functions a) Spot laser- measure height; Thru-beam lasers and receptors- measure diameter; Connection points- recording of measurements simultaneously; Electronic balance- measure mass; b) Ceramic tensiometer- measure soil-water potential; Support platform- house pressure transducer and retain core c) Top view of TypoSoil™ measurements

## MATERIALS AND METHODS

Two native Aridsoils in the State of Qatar (Rodah: silty clay loam and Sabkha: silty loam). Three replicates of reconstituted and undisturbed soil samples of each soil type were measured approximately every ten minutes from saturation to dry state over a period of 2-4 days at 40°C (Approx. 300-600 data pairs).

Reconstituted cores were constructed from air dry aggregates between 200µm and 2mm by capillary wetting before a cycle of drying and wetting. Undisturbed cores were taken from the field using sampling rings that were driven into the surface layer of the saturated soil.

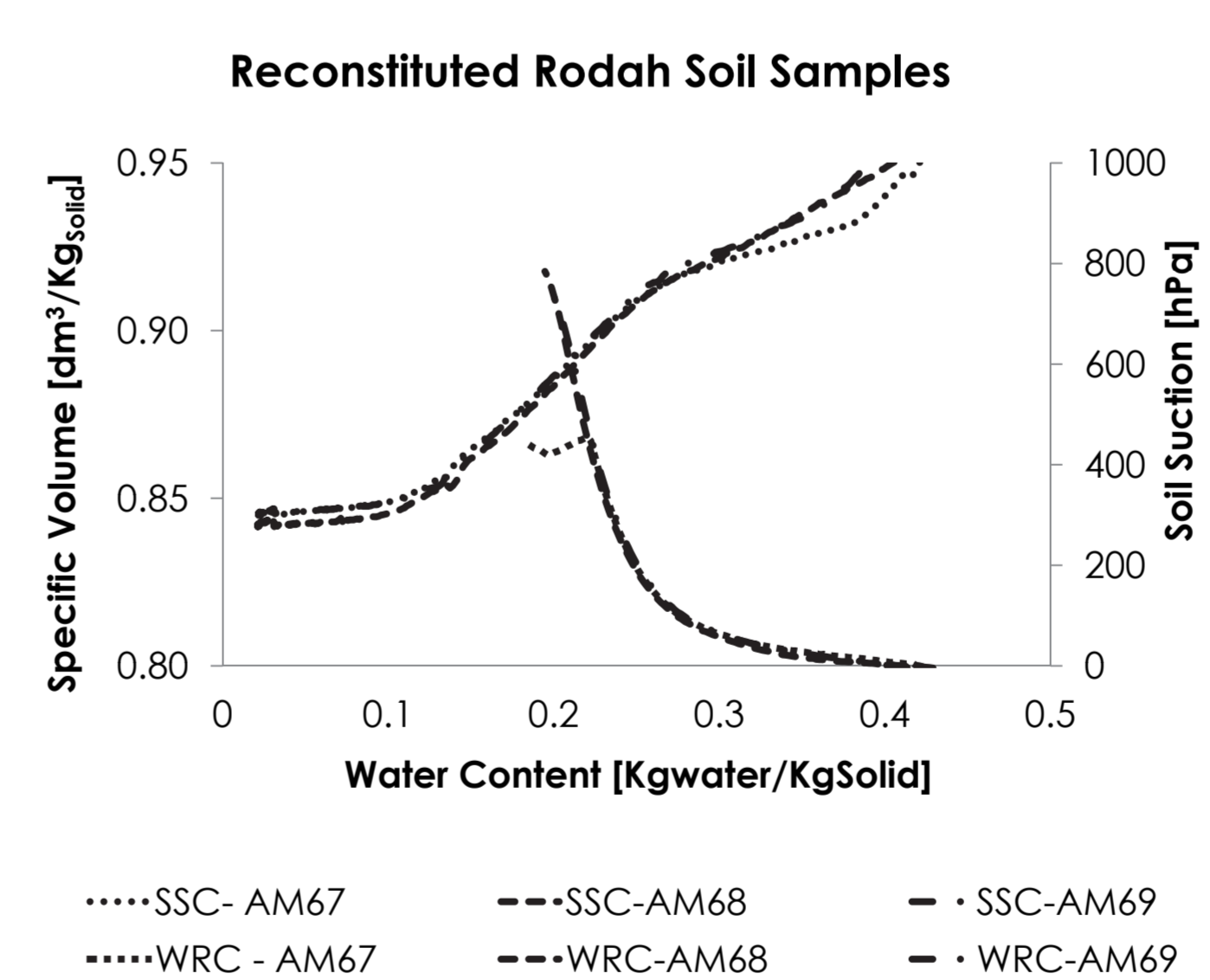
From the continuous measurements the extraction and estimation of 9 characteristic parameters of the podostructure can be used to describe its hydro-structural behavior ( $W_{miSat}$ ,  $W_{maSat}$ ,  $E_{mi}$ ,  $E_{ma}$ ,  $V_o$ ,  $W_N$ ,  $K_N$ ,  $K_{bs}$ ,  $K_{st}$ ). The parameters:  $W_{miSat}$ ,  $W_{maSat}$ ,  $E_{mi}$ ,  $E_{ma}$  are extracted from fitting with the potential curve, and then the rest of the parameters can be extracted from the shrinkage curve through an optimization fitting process.



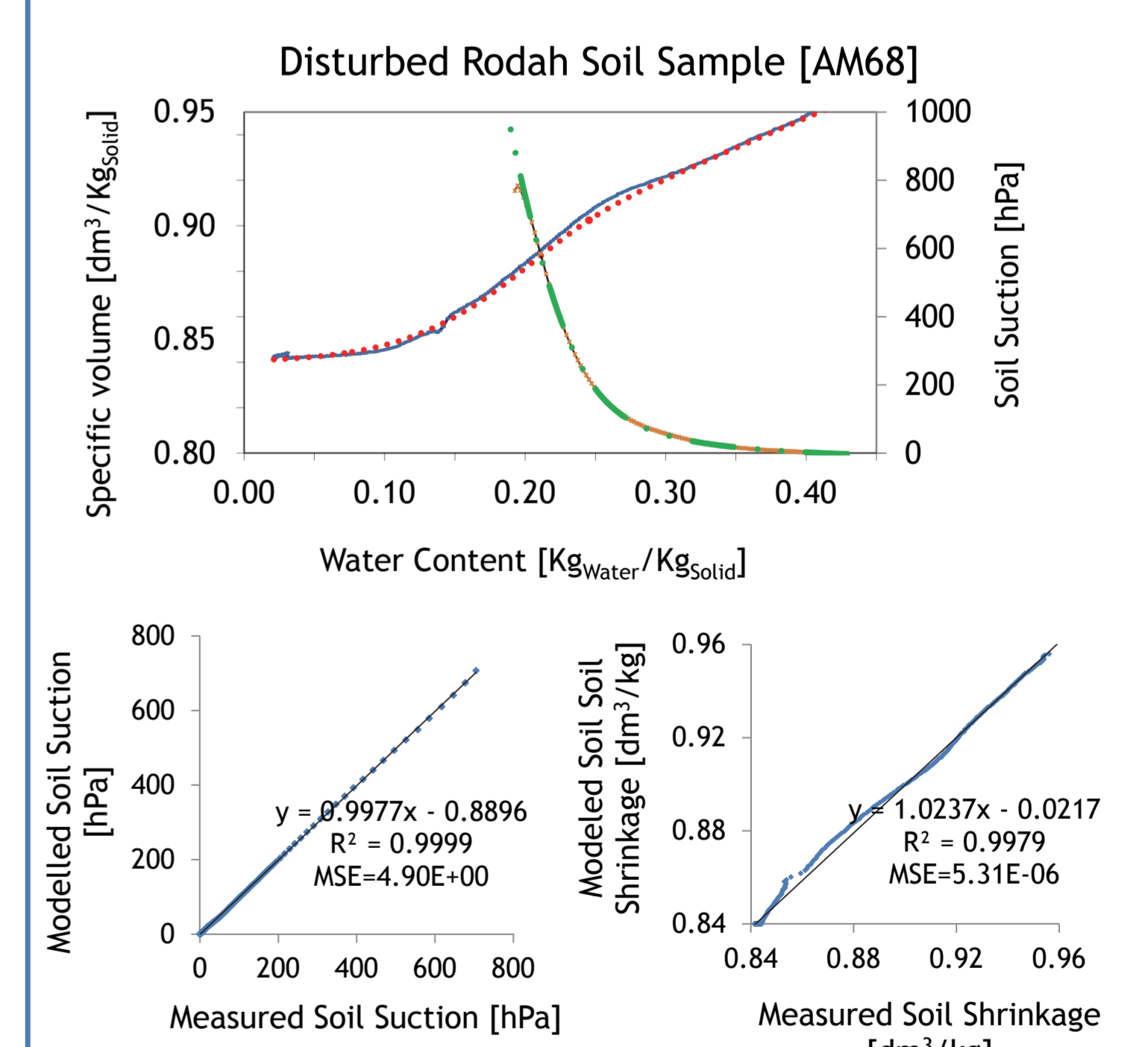
**Figure 4:** Extracting the characteristic parameters of potential and shrinkage curve for the case of sigmoidal shrinkage curve with no saturated interpedal water. Black text indicates that the parameters' values are extracted directly from the curve, while grey text indicates that those parameters are optimized. (from Assi et al., 2014)

## RESULTS AND DISCUSSION

The measured curves for each soil category show consistent and repeatable potential and shrinkage behavior, with slight exceptions. Also, the methodology of parameter extraction is validated by demonstrating that the modeled curves of each core highly correlate with the continuous measurements that would not be possible with a few discrete measurements. When comparing cores of the same type the extracted parameters showed little variation, but were characteristically different from other soil types and constructions.



**Figure 5:** Measured soil moisture characteristic curves: potential and soil shrinkage curve for the three replicates of reconstituted Rodah soil samples. (Assi et al., 2014).



**Figure 6:** Modeling the soil moisture characteristic curves for the disturbed Rodah soil samples. (Assi et al., 2014)

## CONCLUSIONS

The measurement and parameter extraction methodology are validated to be simple, robust, and unique for describing both the potential and shrinkage curves. For this methodology to be used, it is imperative to have continuous and simultaneous measurements, currently only possible with the TypoSoil™ apparatus. The results from the two Qatari soils demonstrated that the results from this methodology were both repeatable within the same soil type and distinctive between different soil types.

## References

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