

and the weights in the layer(s) with L2 regularization applied are all very close to 0

Sounds like you are assigning too high a weight to the regularization term.

L2 regularization literally regresses the weights to 0, so if you are weighting this term too high in your loss, you would observe 0s for your weights.

I would try to decrease the L2 regularization factor and see if that helps.