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**USBM Cell a Useful Stress Measurement Tool MMS's experience**

***Background***

The USBM cell was used extensively in the 1970's. In the early development stages of the CSIRO HI cell, it was used by CSIRO and others to validate the HI cell.

The USBM cell is a two dimensional device and as such it only measures stresses in a plane perpendicular to the borehole. In order to measure the three dimensional stresses, measurements are required in a minimum of two non parallel boreholes. However, to confidently determine the three dimensional stresses, three non co-planar boreholes are required, with about three tests (overcores) in each borehole.


MMS initially acquired the USBM cell for use at a mine in Queensland to determine the 3D stress field, where a previous attempt at overcoring CSIRO HI Cells in the same rock unit failed. A satisfactory bond between the HI Cells and the pilot hole could not be achieved.

MMS has developed software that can be used to determine the 3D stresses from USBM tests conducted in three holes. This code was checked against an independently developed code by the United States Bureau of Mines. Very good agreement was achieved by comparing stress outputs from the MMS and USBM codes.

As the USBM cell is reusable and does not require grouting the instrument into the borehole, it can be quite a rapid testing tool. MMS has achieved four overcore tests and four biaxial tests in one day.

Since using the USBM cell to determine the 3D stress field at the mine above, MMS has been using the USBM cell on a routine basis to gain more strain data at sites where MMS conducts CSIRO HI cell tests. This data is then included with the CSIRO HI cell data to determine the site 3D stress result.

The USBM cell has also proved invaluable in obtaining more rock property data. In some cases where the HI cell core has broken and a biaxial test on this core was not possible, the USBM cell was inserted in the same core and biaxially tested. The modulus obtained was then used in the analysis to determine the stresses for the HI Cell.

Another useful application of the USBM cell is when discing of the core is encountered. At one recent mine site we encountered discing of the core in a borehole to approximately 4 m depth. Two USBM tests were conducted immediately after the discing to determine the stresses that were required to cause discing of the core.

The USBM cell may also be useful in pillars where only the 2D stress field is required, and rapid testing can be performed.

### *MMS USBM Cell and CSIRO HI Cell Comparison*

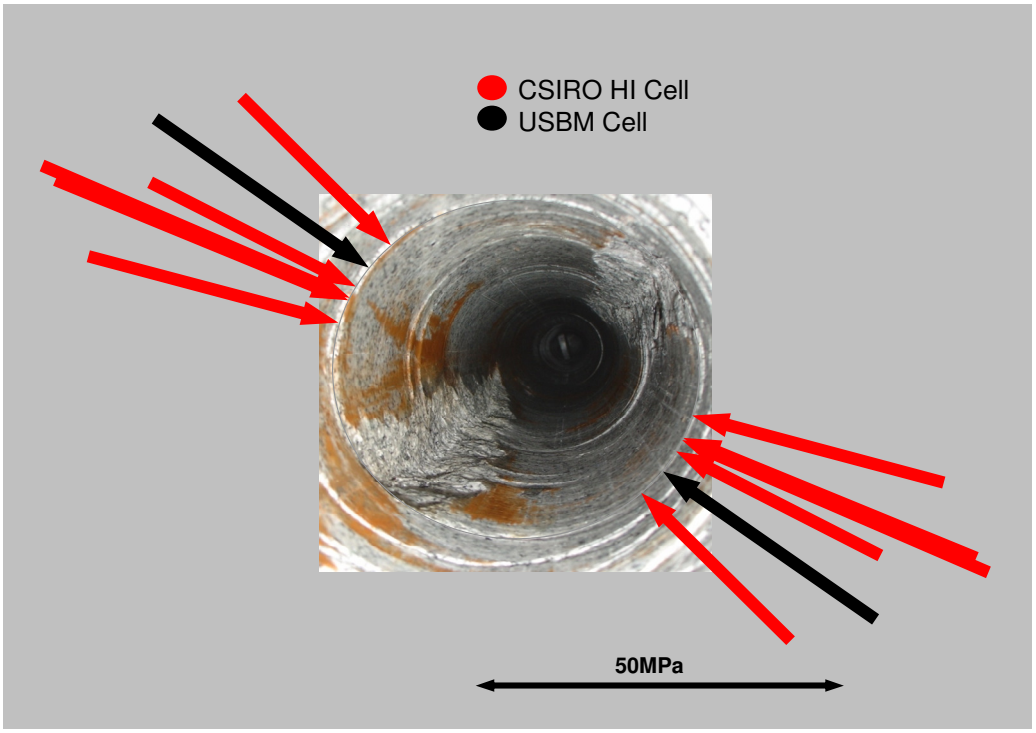
Below is a comparison of the USBM cell data and CSIRO HI Cell data to date that have been conducted by MMS.

As the USBM cell only measures the maximum and minimum stress normal to the borehole (magnitudes and directions), the CSIRO HI cell results have been rotated to obtain the maximum and minimum stresses in the borehole.

To calculate the secondary principal stresses for the USBM cell, two formulas can be used; one which assumes zero stress in the borehole direction (plane stress condition) and the second, a more exact solution where the axial stress in the borehole is included (plane strain).

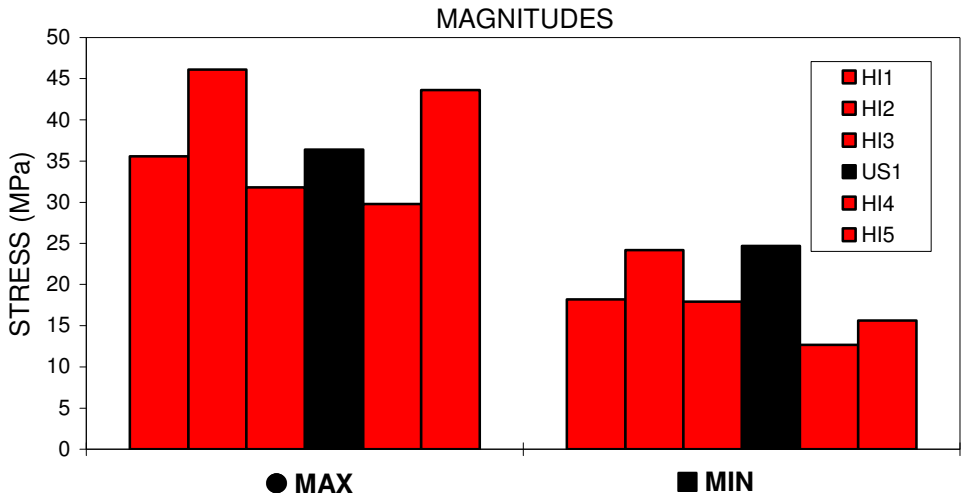
In MMS's comparisons we use the more exact solution. We are able to rotate the stresses obtained from the CSIRO HI cell results and determine the stress in the axial direction of the borehole and use this to calculate the secondary principal stresses for the USBM cell.

## Maximum Stress Direction




Looking in hole

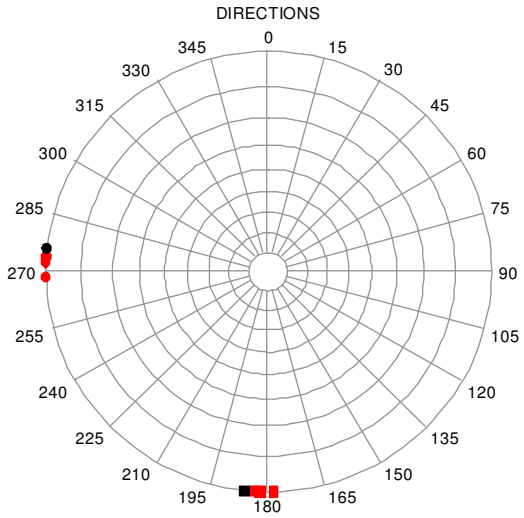
Maximum and Minimum Magnitudes



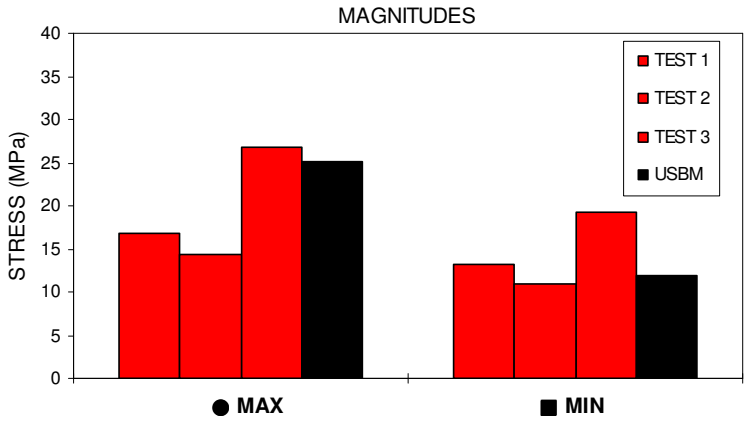
## SITE 1 Secondary Principal Stresses Around Hole

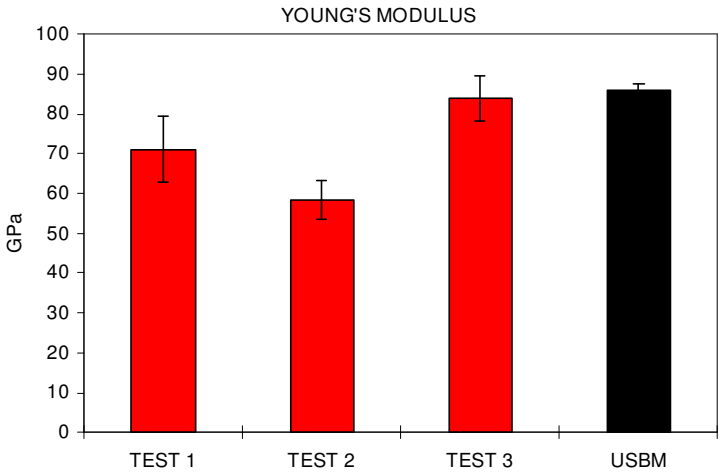
HI Cell

USBM Cell




LOOKING INTO HOLE

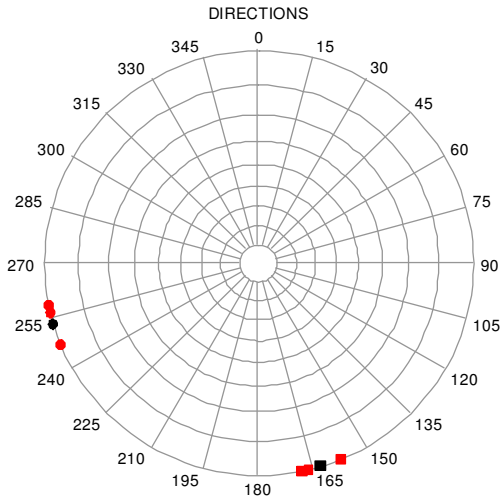


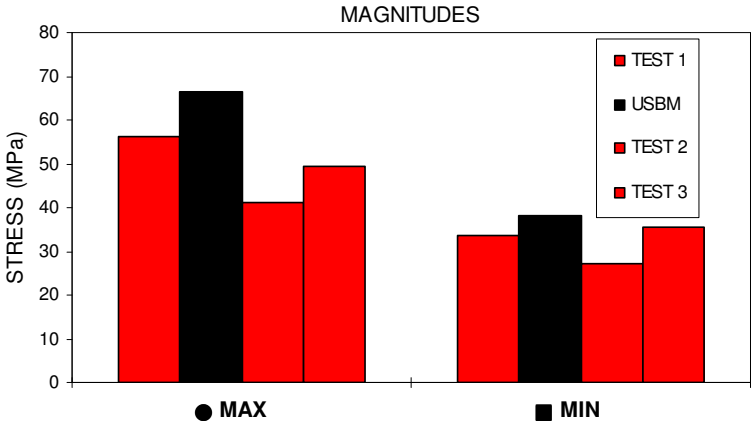
## SITE 2 Secondary Principal Stresses Around Hole

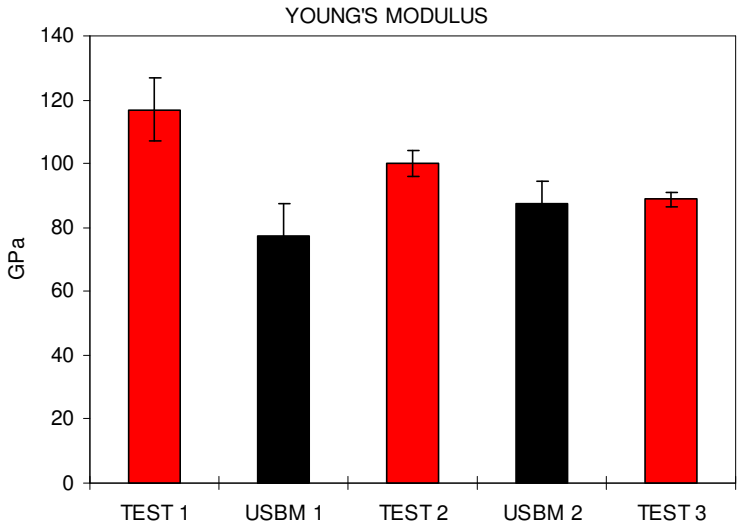
HI Cell

USBM Cell




LOOKING INTO HOLE

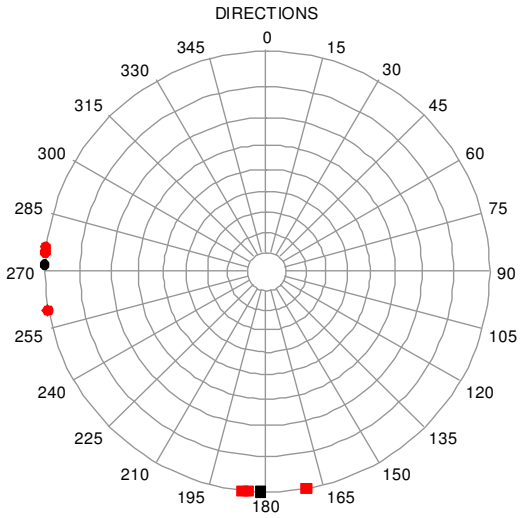


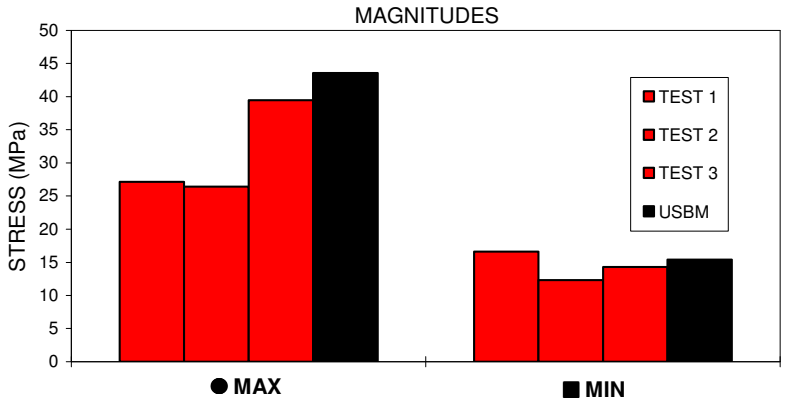
## SITE 3 Secondary Principal Stresses Around Hole

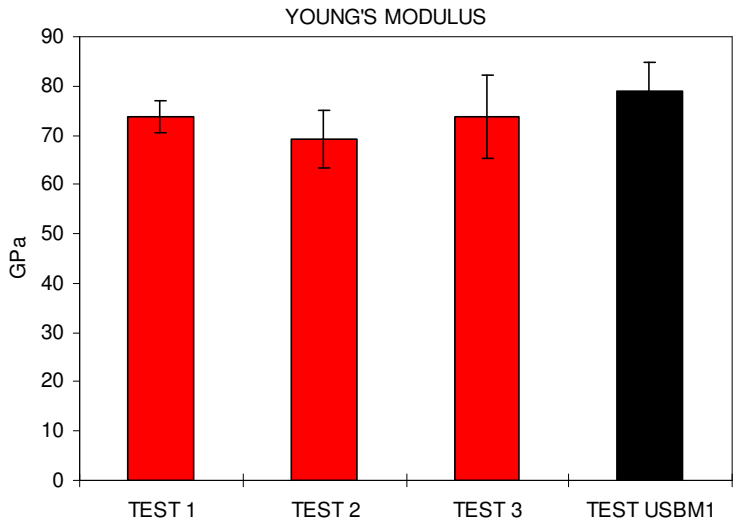
HI Cell

USBM Cell




LOOKING INTO HOLE

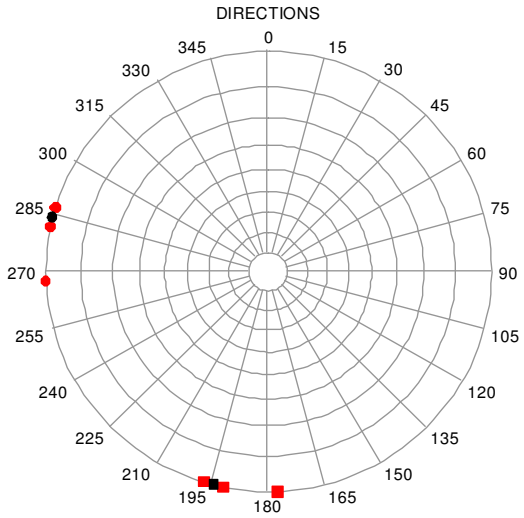


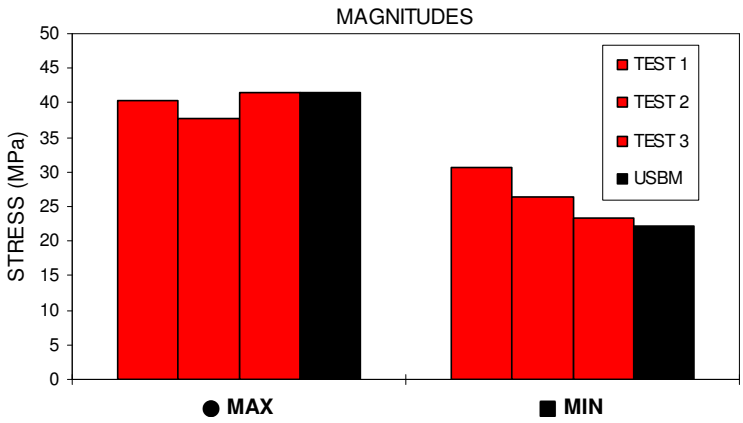
## SITE 4 Secondary Principal Stresses Around Hole

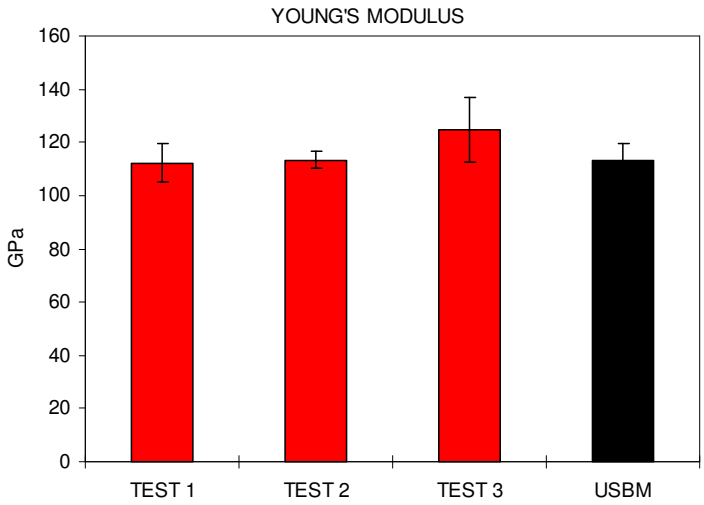
HI Cell

USBM Cell




LOOKING INTO HOLE

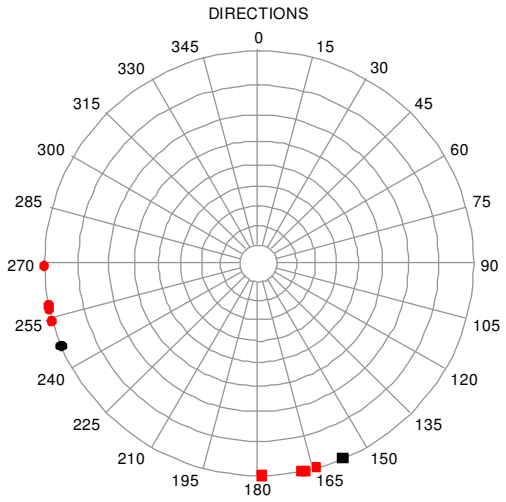


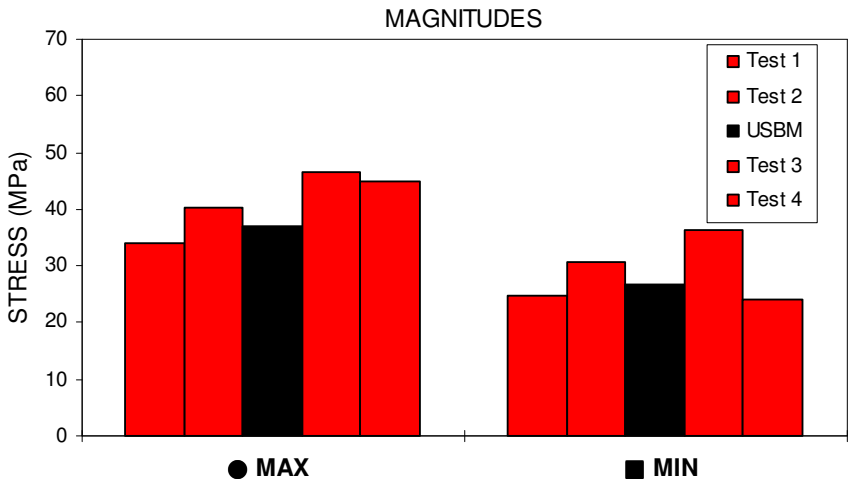
## SITE 5 Secondary Principal Stresses Around Hole

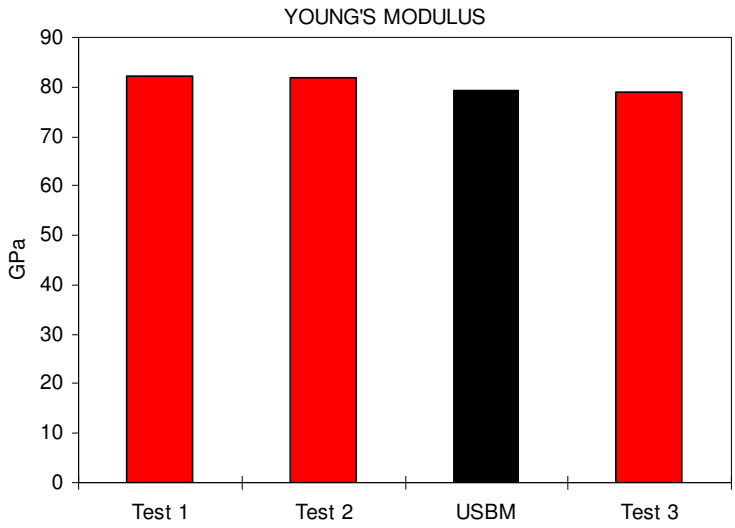
HI Cell

USBM Cell

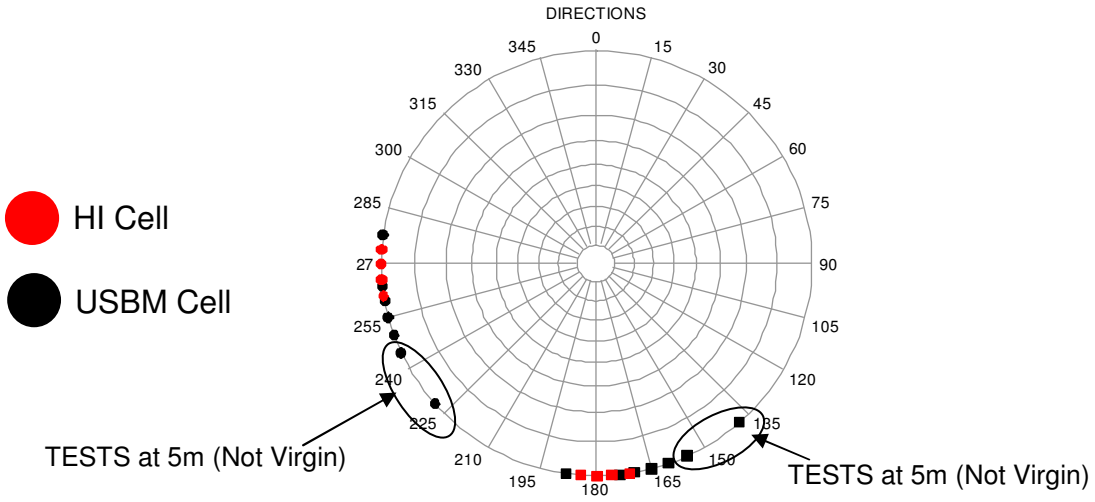



LOOKING INTO HOLE

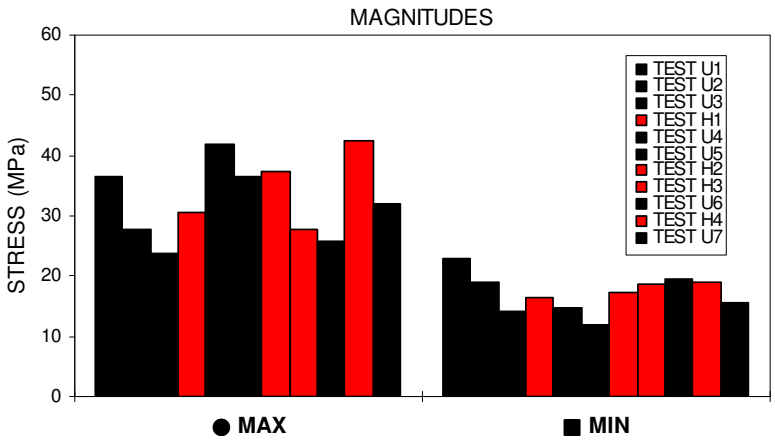


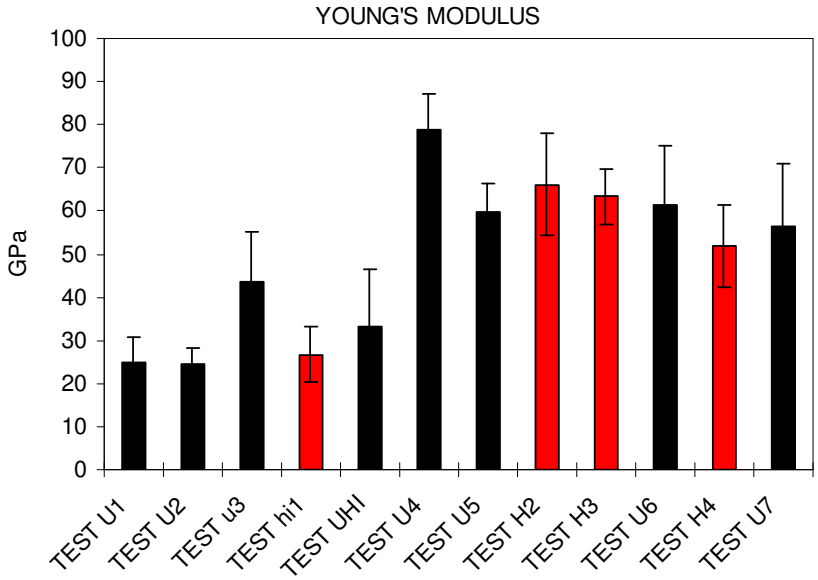



## SITE 6 Secondary Principal Stresses Around Hole

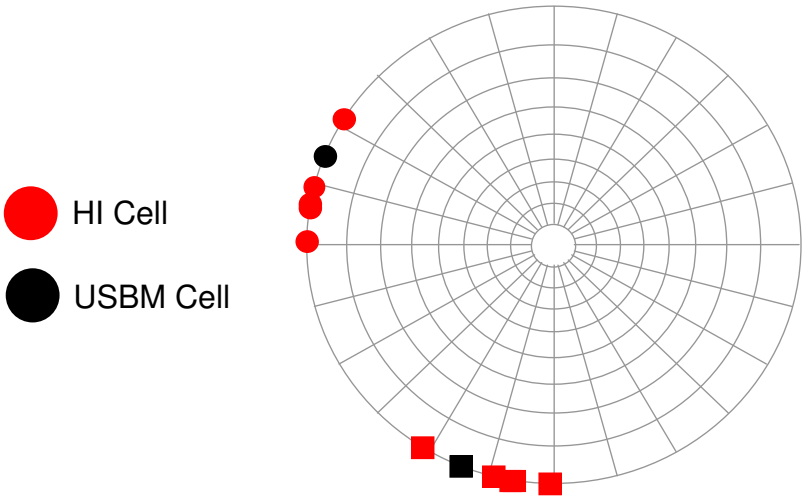



LOOKING INTO HOLE

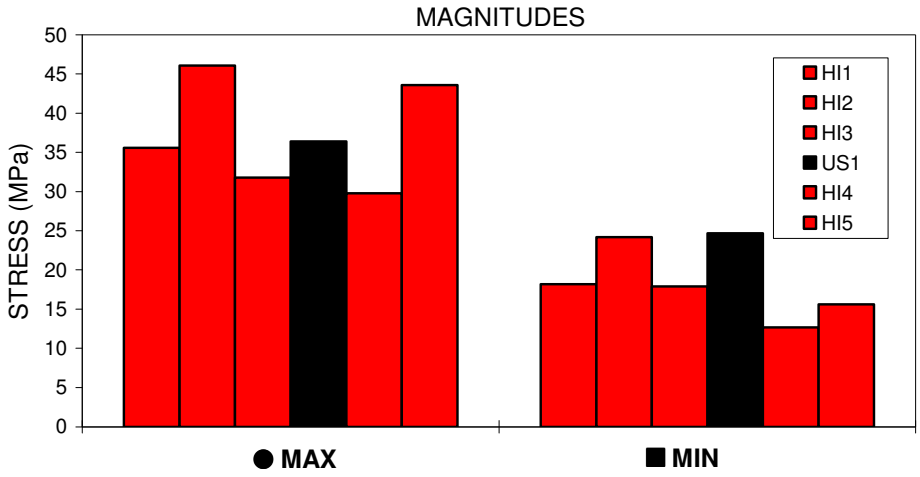


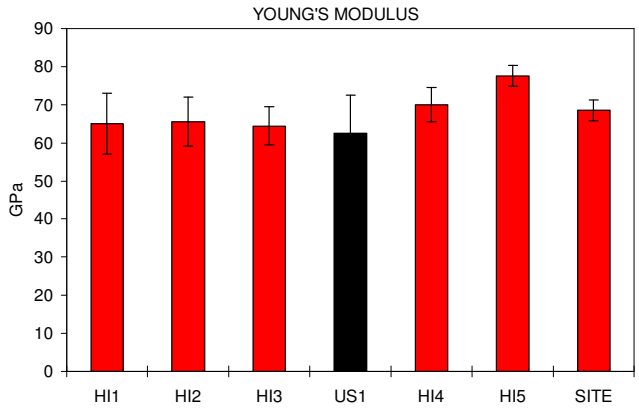



## SITE 7 Secondary Principal Stresses Around Hole

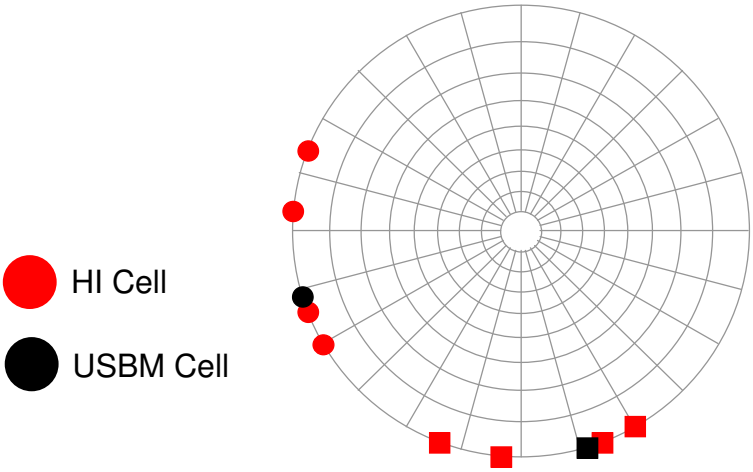



LOOKING INTO HOLE



## SITE 8 Secondary Principal Stresses Around Hole

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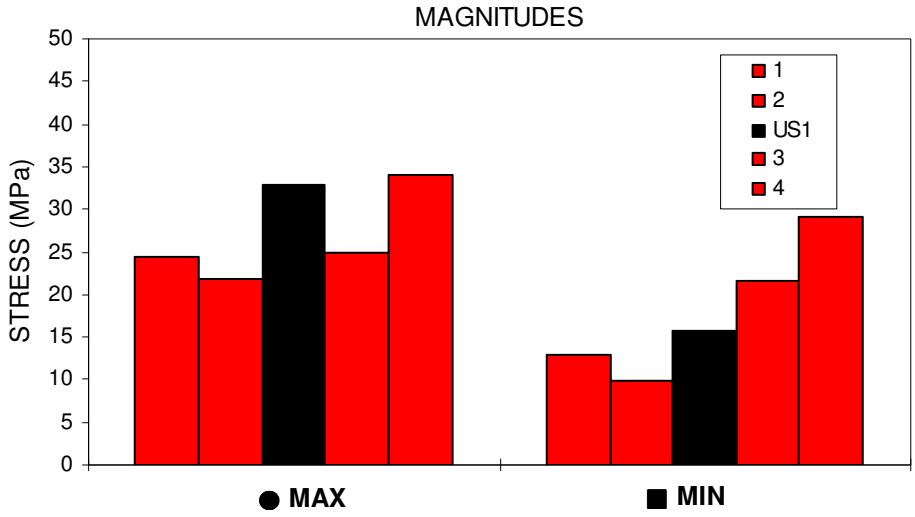
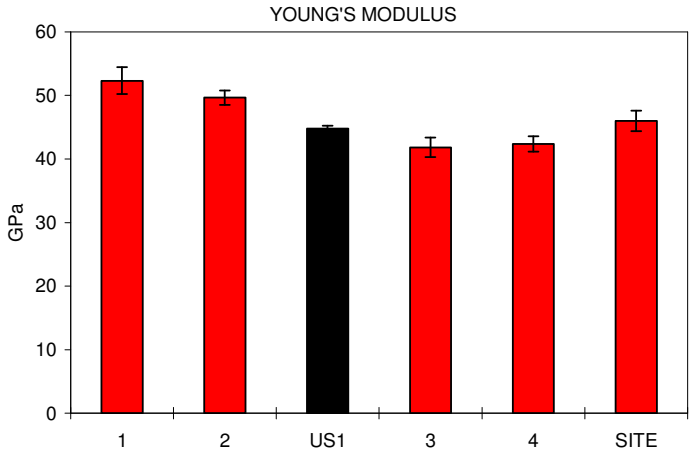
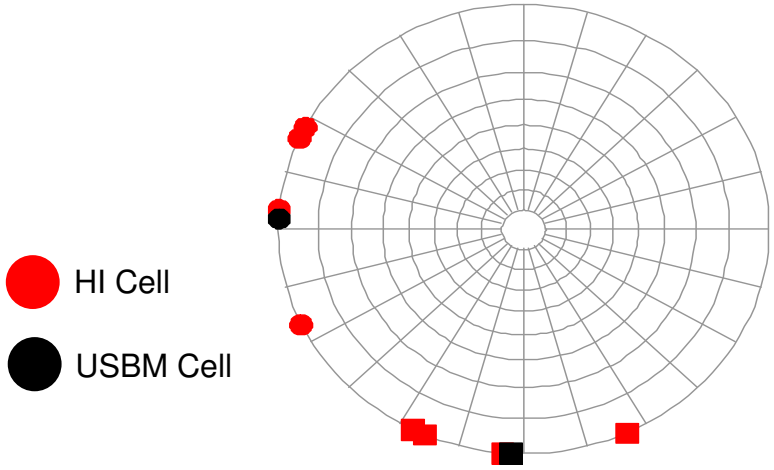
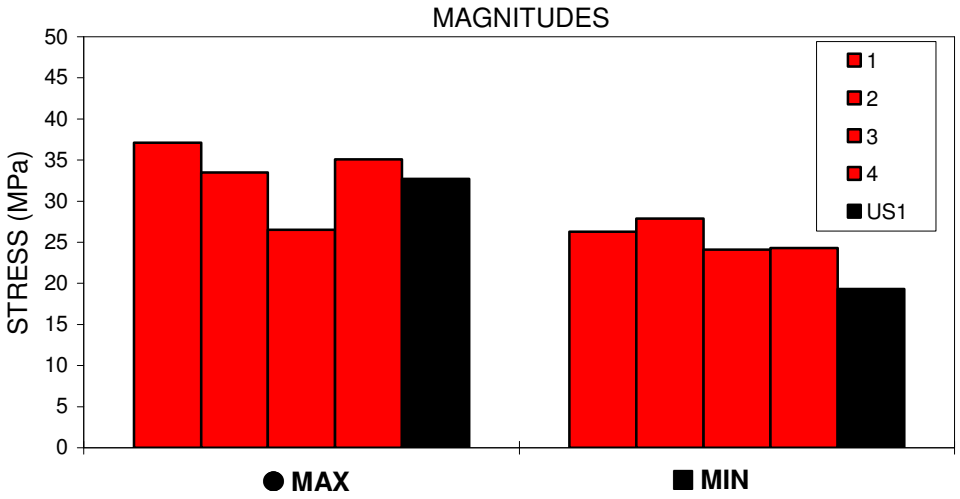
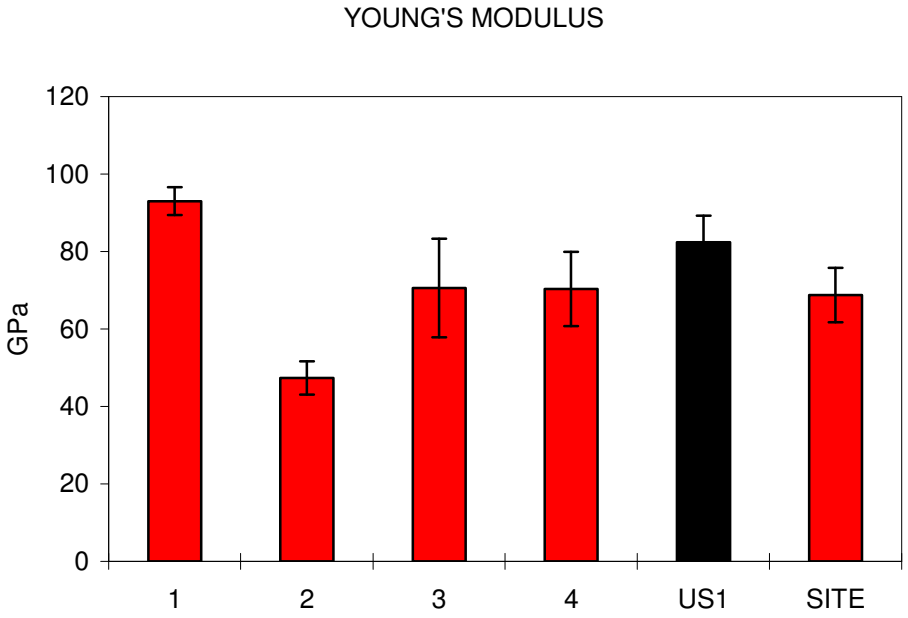


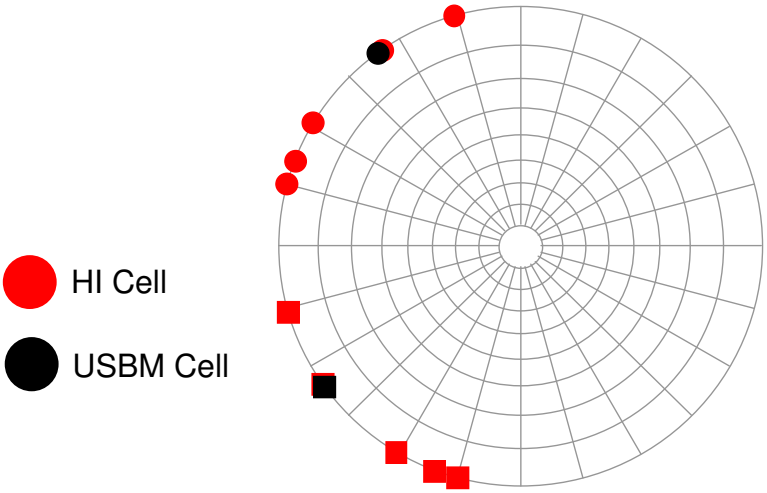
## SITE 9 Secondary Principal Stresses Around Hole



## SITE 10 Secondary Principal Stresses Around Hole

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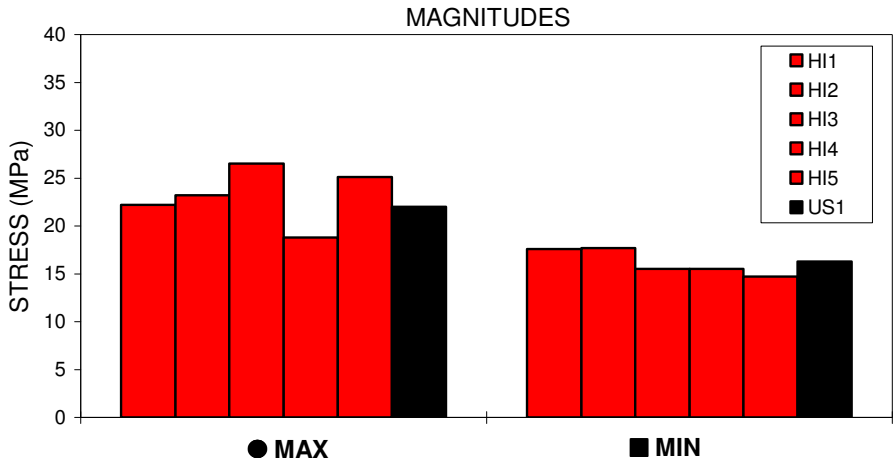


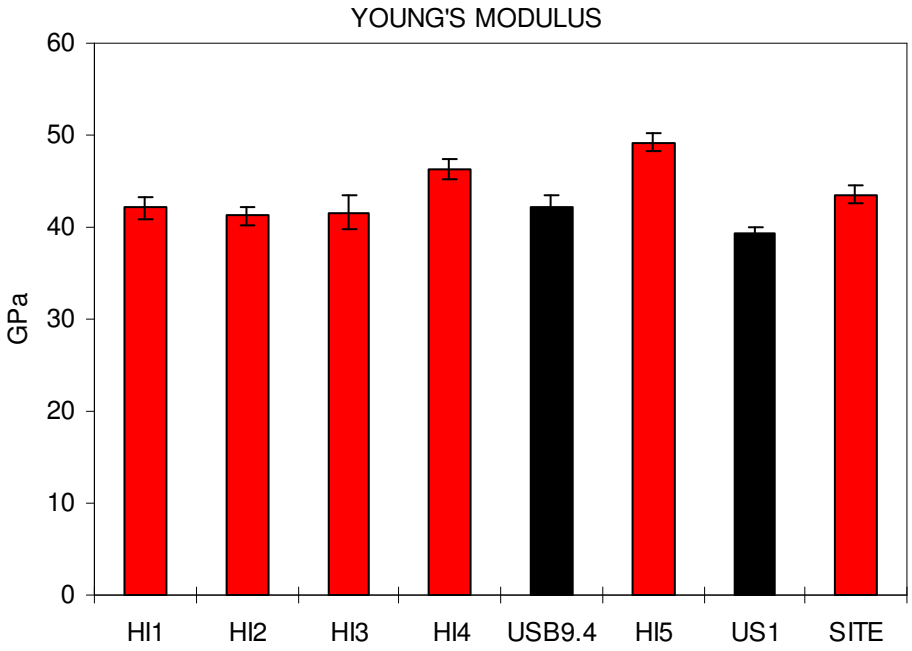

## SITE 11 Secondary Principal Stresses Around Hole