A GOLDMINE GOLD
A goldmine Gold Mine
Sag Mill

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Client	A goldmine Mining	A goldmine Gold
Inspection Date		17th August 2016
Order Number	Purchase Order No	

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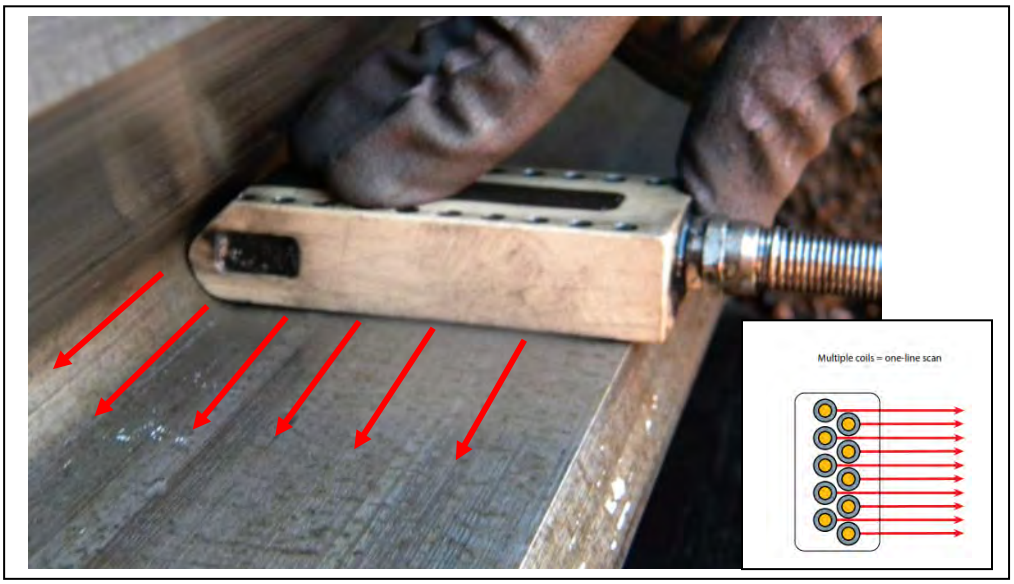
1. Scope:

NDT and inspection of A goldmine Gold mining's – A goldmine Gold mines Sag Mill girth gear. The principal objective is the detection of fatigue cracking that poses a risk to the continued operation of the ball mill and report significant anomalies.

Inspection Process:



The inspection consists of passing a 32 coil array probe over the surfaces of the teeth and the root area. An array of coils ensures that the entire depth of the gear tooth is scanned for cracks and geometric upsets. First the load side and the root are inspected – labeled as the A scan then the unloaded side named the B Scan. If the mill is routinely run in both directions –then the A and B is arbitrary.

Analysis print outs of reportable defects are included in this report along with associated photographs.

The sensitivity of the scanning equipment is tailored to detect significant anomalies and tight fatigue or overload cracks.

Due to the nature of the Process interpretation is intuitive and reporting is by exception.

2. Inspection Results

No reportable fatigue cracks were detected on the current contact flank. The gear flank does, however bear the results of contaminant ingress - more on that is section 3.

The gear has 280 teeth resulting in 560 scans – as both the loaded flank and unloaded flank were inspected.

The gear was found to be in serviceable condition - The unloaded flank has been used previously and would be considered as unserviceable unless some significant remedial work were carried out on it.

The numbering stamped on the gear was found to be in error. It was supposedly stamped every 10 teeth and errors in counting emerge between tooth 10 and 20 - and the error varies from 1 tooth to 5 teeth. It is suggested that this number stamping be corrected when the opportunity arises.

Table 1 Eddy current voltages by actual tooth number - the higher the voltage - the greater the magnetic interruption and therefore the greater the material anomaly.

Tooth Number	Eddy Current Voltage	Tooth Number	Eddy Current Voltage	Tooth Number	Eddy Current Voltage
019 A	2.05	137 A	3.02	202 A	2.37
027 A	3.51	144 A	2.42	219 A	3.47
041 A	2.04	146 A	2.50	221 A	3.66
060 A	2.07	152 A	2.67	222 A	2.35
061 A	2.20	157 A	2.33	223 A	3.95
098 A	**8.29**	**160 A**	**4.82**	229 A	3.72
118 A	3.15	164 A	2.92	253 A	4.06
126 A	3.26	177 A	2.54	259 A	2.30
129 A	2.76	181 A	3.02	**273 A**	**5.61**

Gain = 43dB
Max voltage on calibration plate: 7.78 Volts

The instrument is set to a differential measurement - whereby disturbances to the magnetic signature are so minor under these conditions it is appropriate that only abrupt changes such as pits and cracks feature on the readout.

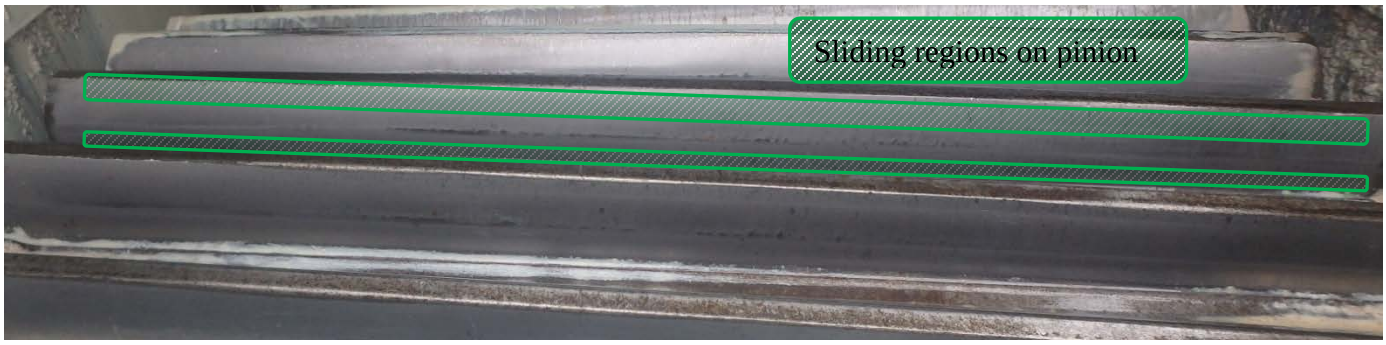
3. Observations

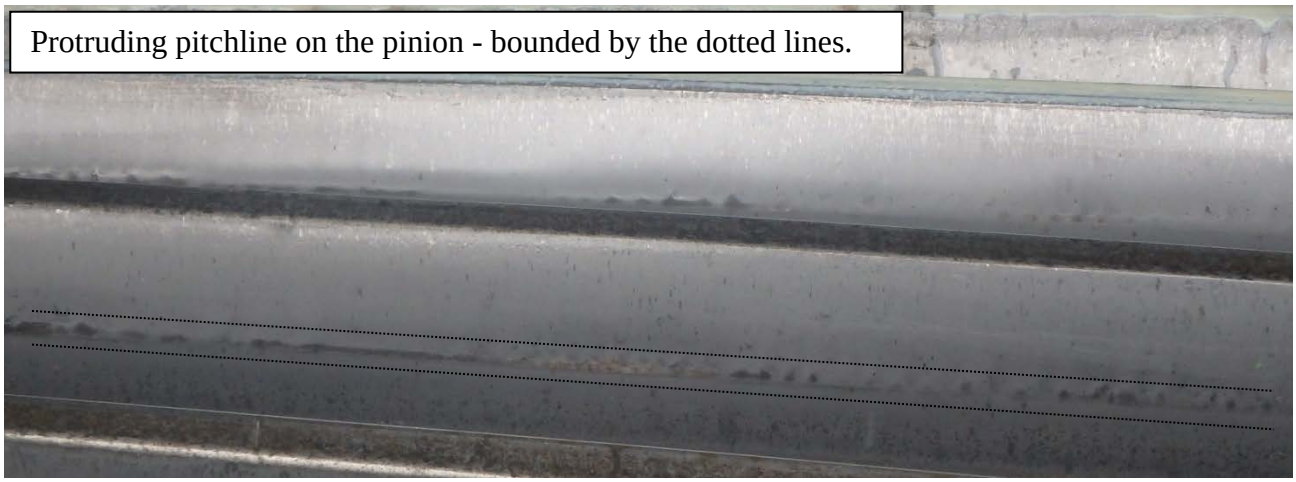
The gear has obviously experienced ingress of abrasive contaminants in the past. Contaminant wase detected on the gear during the inspection. The use of ultra high viscosity lubricant on the gear set has most likely reduced the effect of the abrasive contaminant.

The girth gear has a depressed pitch line. This coincides with a slightly raised pitch line on the pinion gear. This would normally indicate that significant wear has taken place with a relatively soft pinion driving the gear. Wear happens in the addendum and de-dendum areas of the gear set. Once the abrasion or wear has taken place it leaves a high pitch line due to the rolling action of the gears.

Recommendations

It would be advisable to remove the protruding pitchline on the pinion by means of a sander and oilstone. Once the pinion geometry is improved - then the deterioration on the girth gear associated with load concentration will be reduced. In the long run (sometime in the next 1 - 2 years) it would be advisable to do the same for the girth gear and reverse the pinion to provide a good medium term outcome.





4. Discussion

The attached paper on gearing faults from MarineEngineering.org.uk a marine engineers forum describes the failure modes of gear very well - including the area of lost material due to either abrasive 3rd body interaction or boundary lubrication and scuffing.

Notes on this inspection report:
Scans:

The scans contain the gear tooth number on the left hand side of the image. This is a print straight from the scan database and the entire screen dump is included to demonstrate the completeness of the scan.

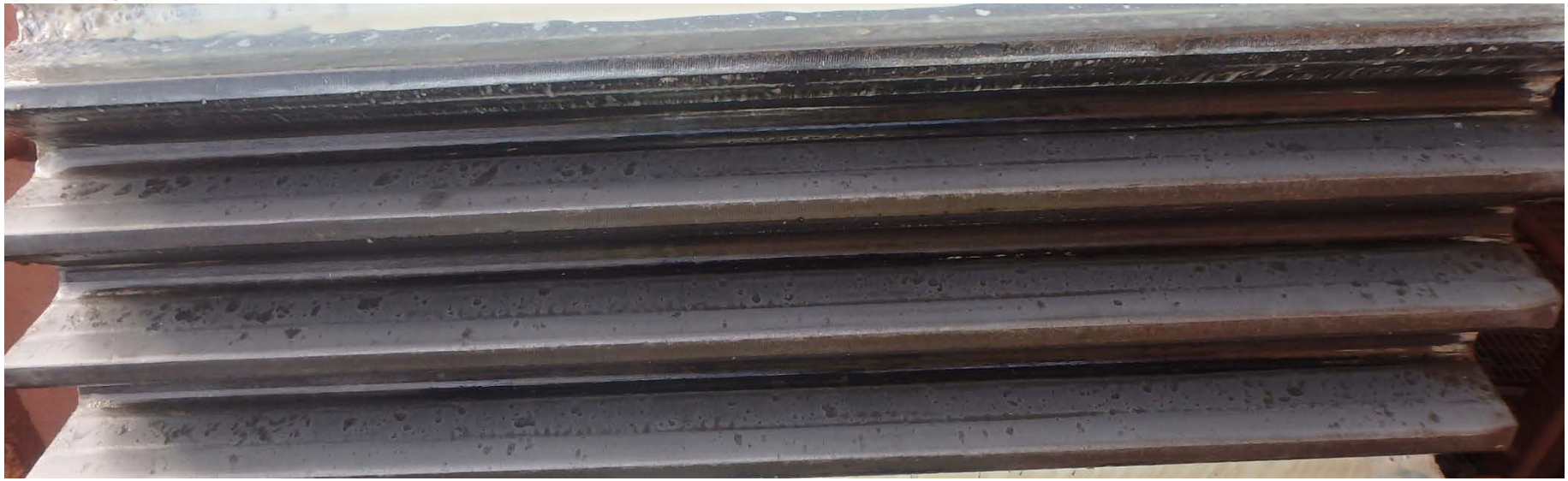
Where there is an anomaly detected during a scan, the tooth is cleaned off and a photograph taken to illustrate what a magnetic anomaly can look like on the surface.

Surface anomalies:
It has been observed that eddy current signals are greatest where the geometry of the anomaly is abrupt such as a deep tight crack or a surface fatigue or case crushing spall.

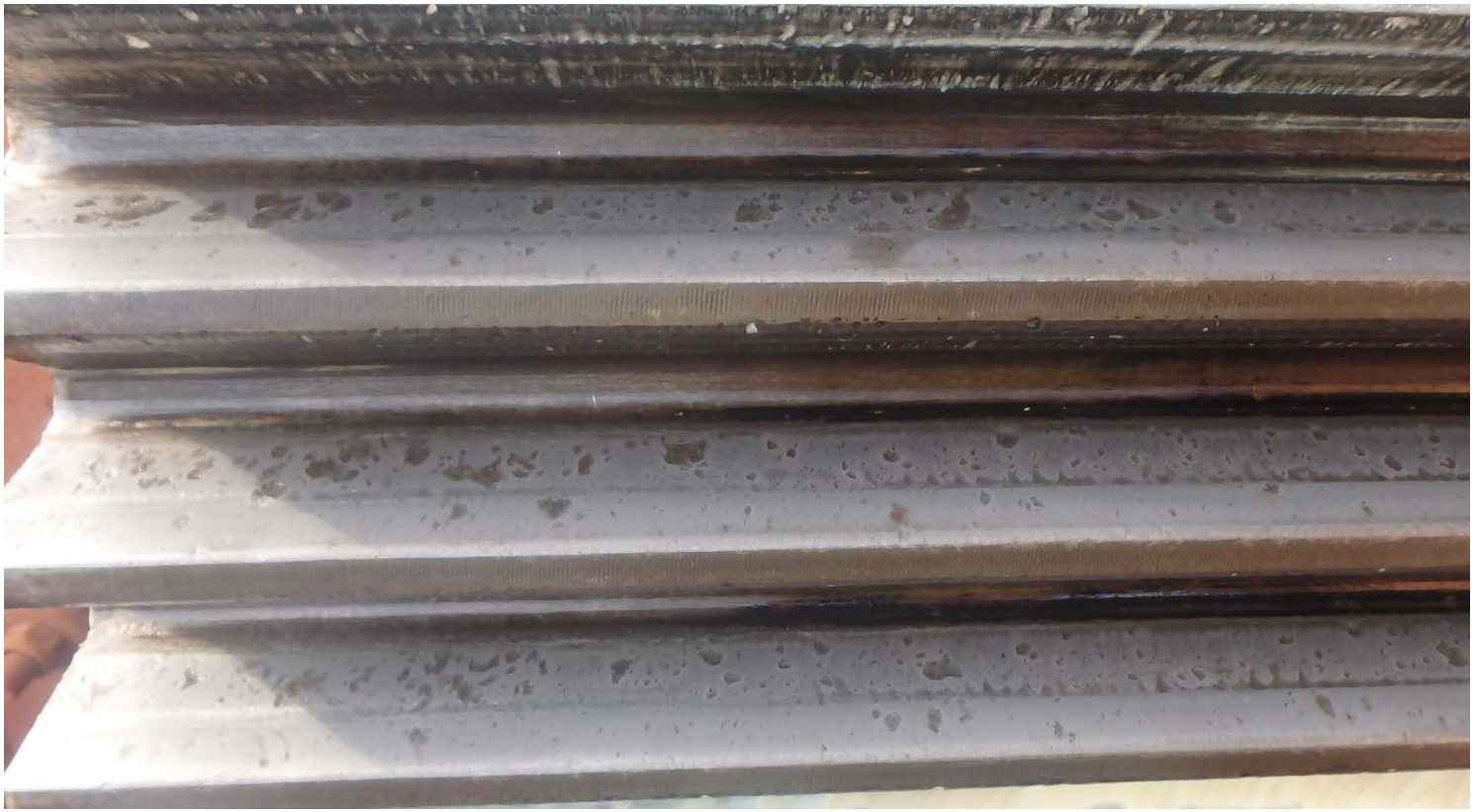
On material surfaces that have significant quantities of material missing, but the transition is gradual and smooth, the signal is much lower and the output to the 3-D isometric image is consequentially not typically red or sharp in appearance.

On this basis there is a good level of confidence of detecting a tight fatigue crack on a gear surface without overly complicating the report with reports of surface pitting and scoring or other abrasive failure modes.

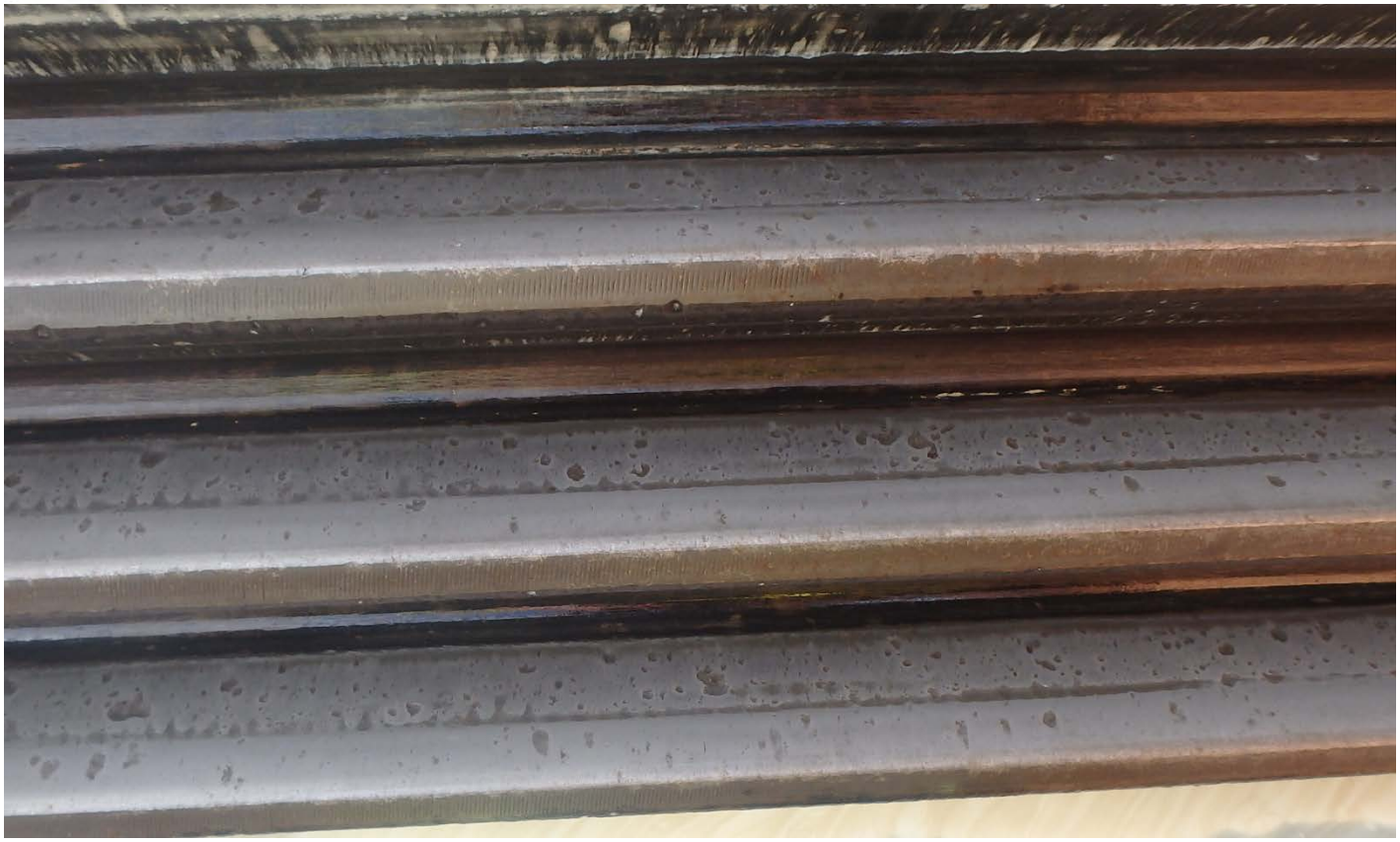
DEFECT PRINTOUTS AND JOBSITE PHOTOS



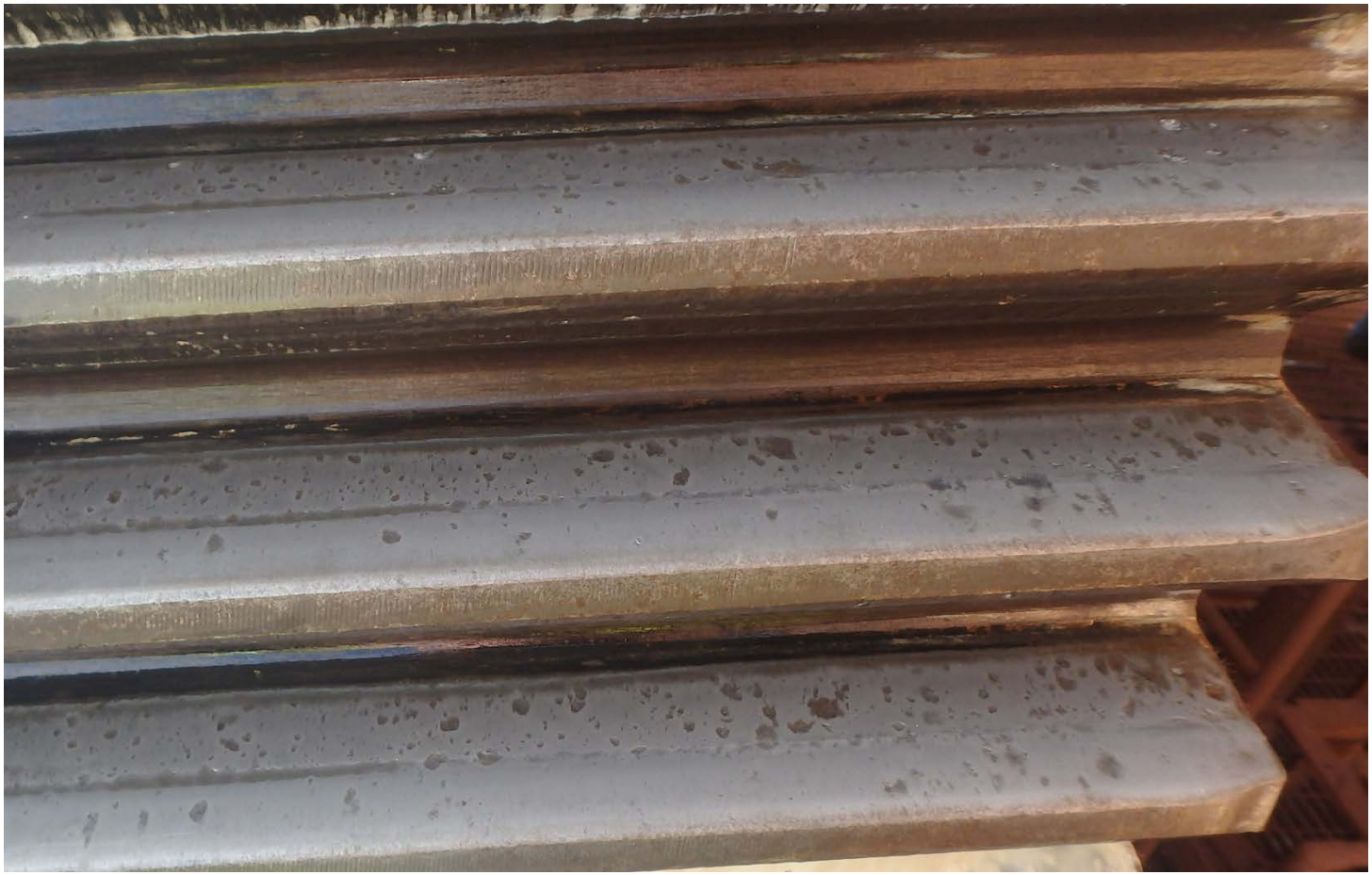
General view of contact flank.



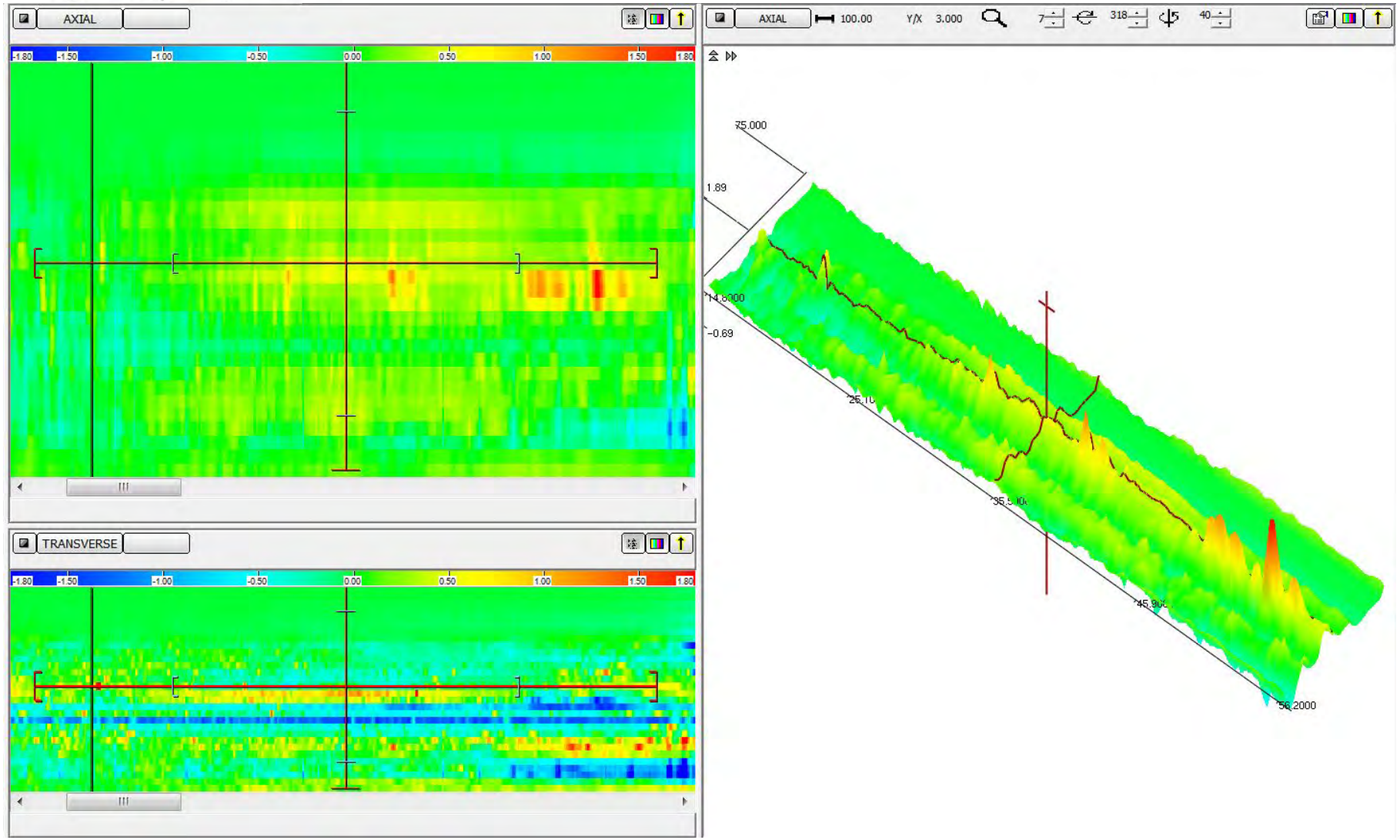
General view of contact flank Non Drive End the dark line indicates a depressed pitchline.



General view of contact flank center region demonstrating more indentations on the dedendum of the tooth.

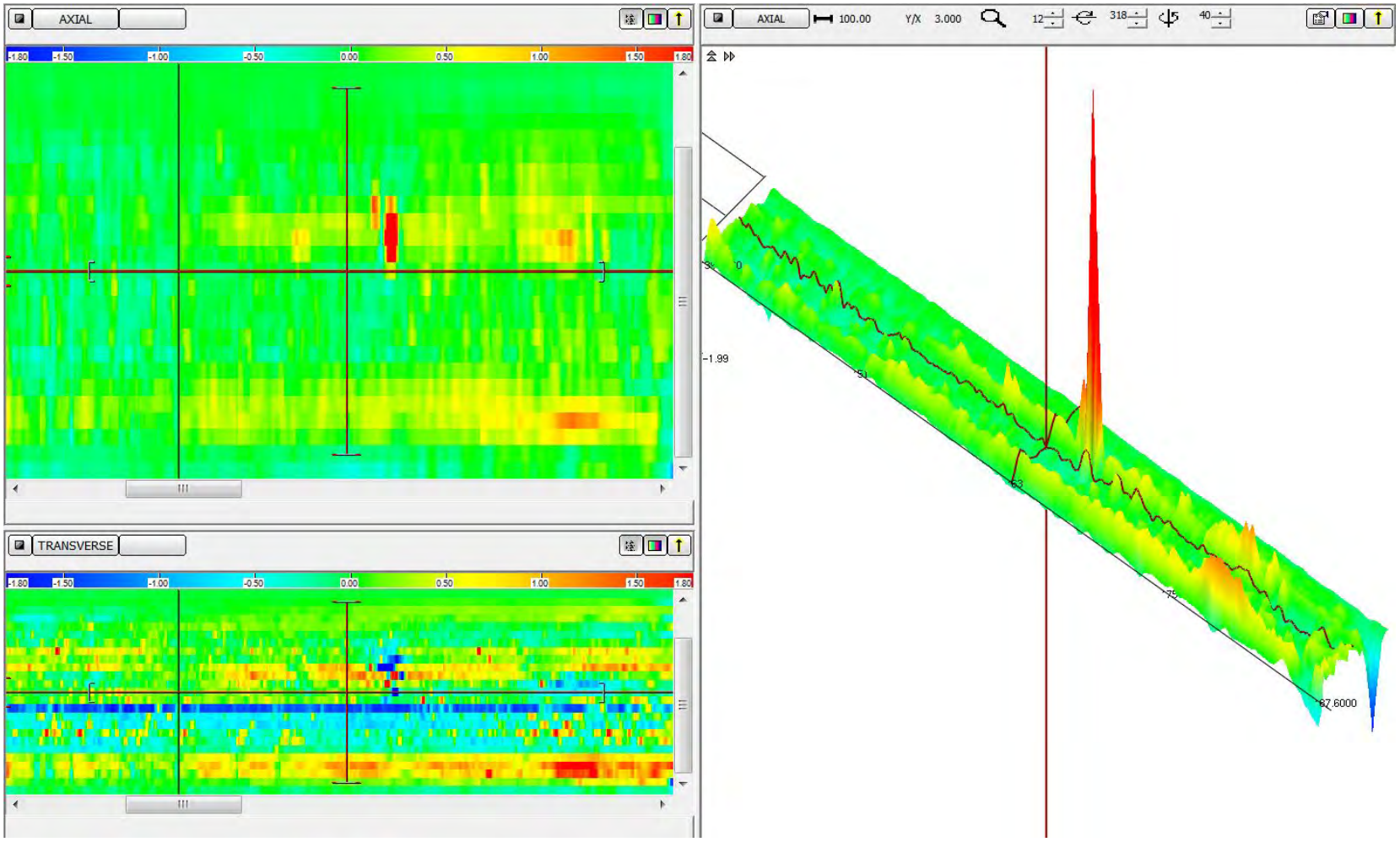


General view contact flank Drive End.



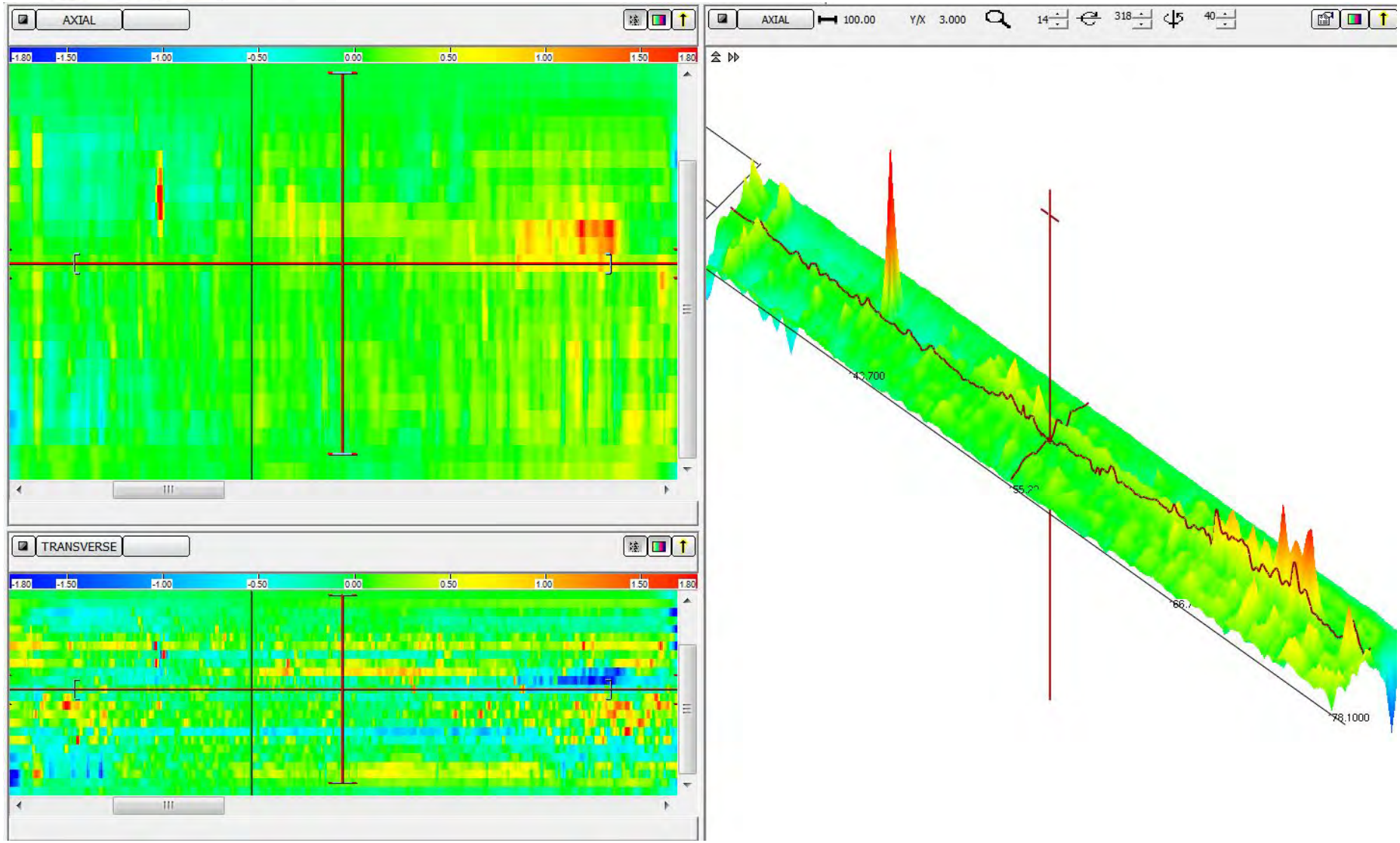
Tooth 196 (pictured above) showing a typical eddy current signal. The eddy current disturbance is greater towards the bottom of the C-scan (the dedendum of the gear tooth). The gain has been adjusted to largely filter out the indentations.

Fatigue pit found on tooth A 98.



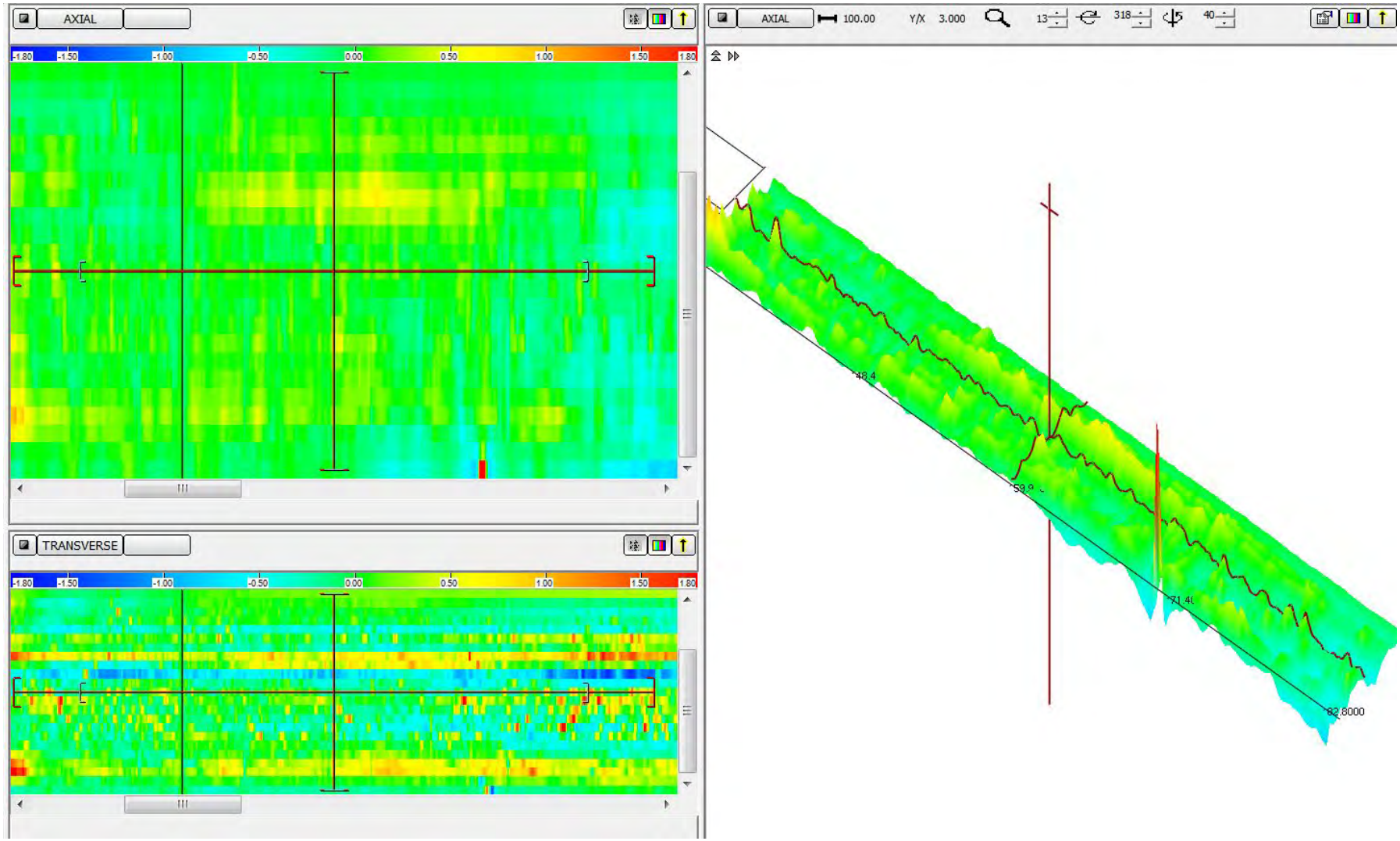
Eddy Current Array Scan of tooth A 98 this anomaly was picked up in 2014 and has not appeared to have deteriorated.

Tooth 118 highlighting the isolated pit.



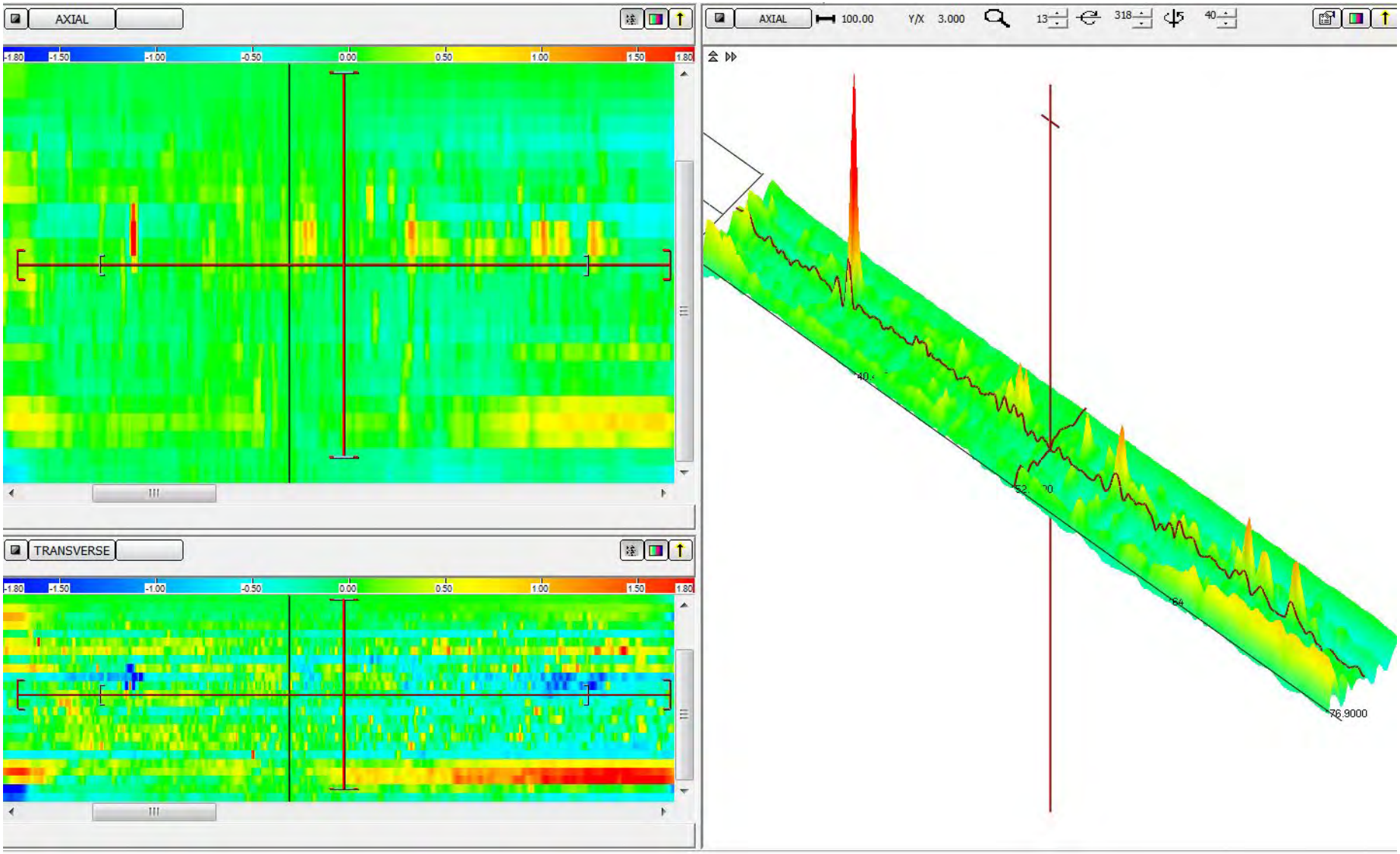
Eddy current array signal for Tooth 118 - showing and isolated pit towards the non drive and a depressed pitchline towards the drive end.

Localised anomaly in the root of tooth 126 A.



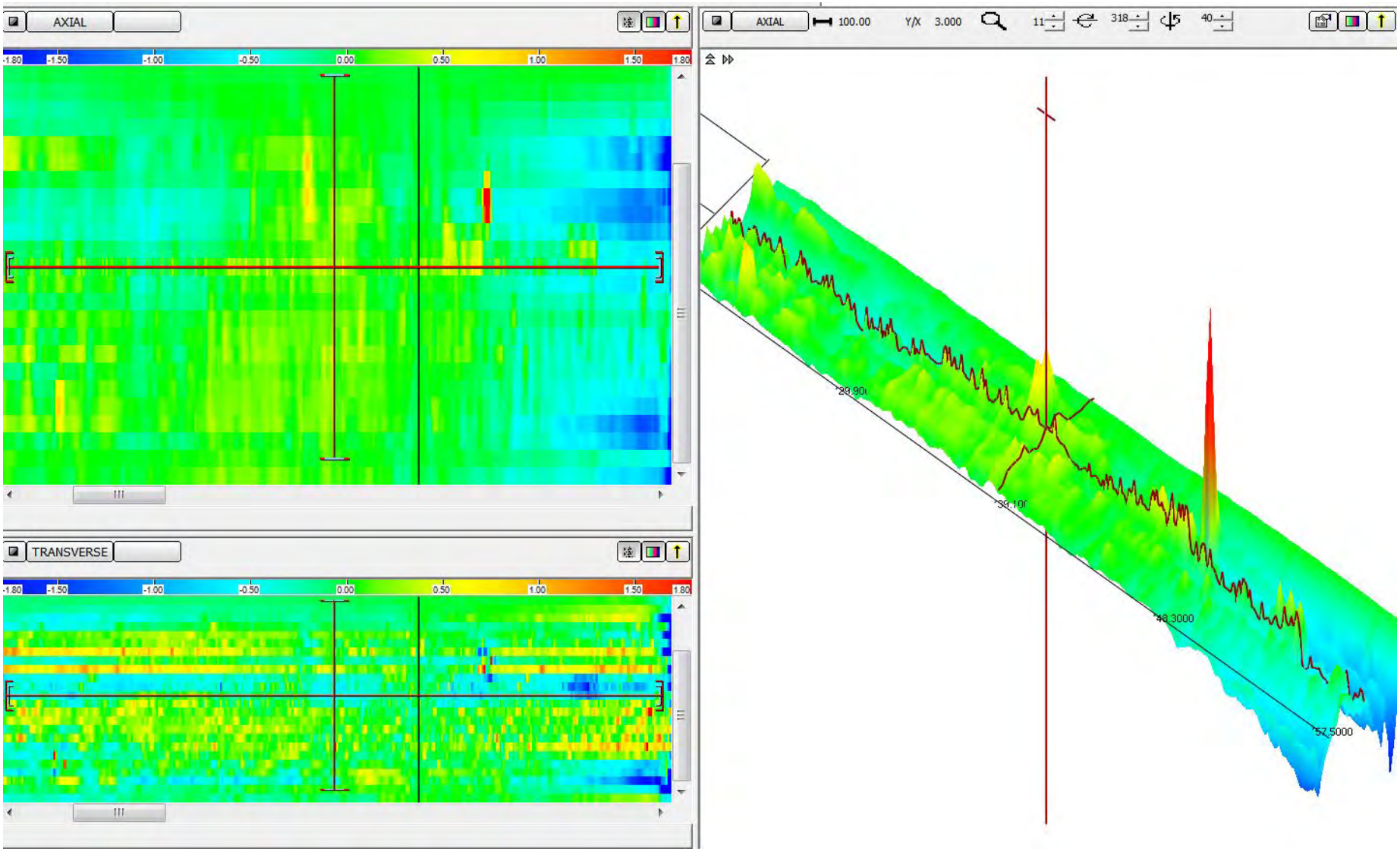
Eddy Current Array Scan of tooth 126 A.

Tooth 160 .



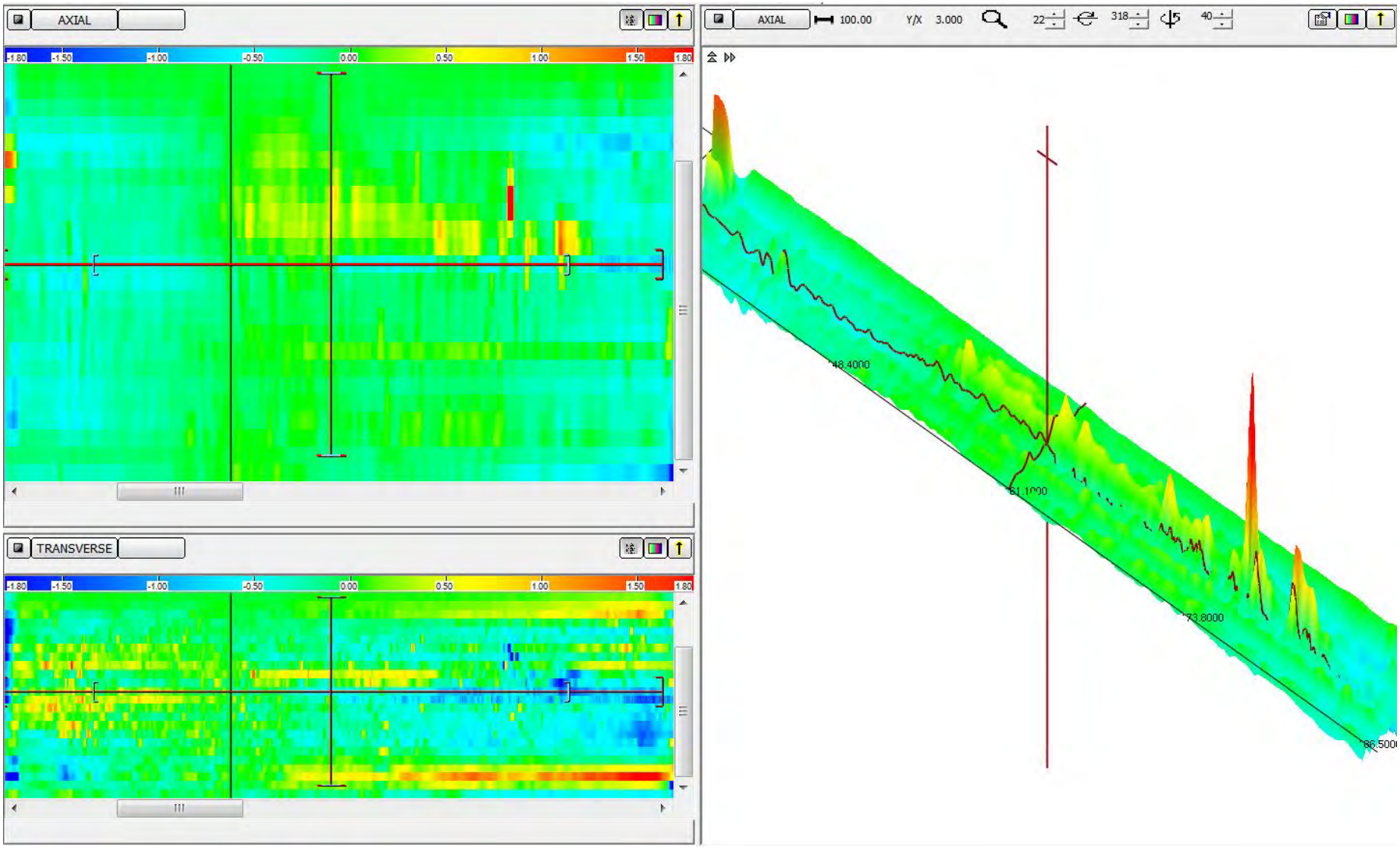
Eddy current array signal for tooth 160 showing an isolated anomaly and some evidence of a depressed pitchline.

Tooth 229 showing a localised pit.



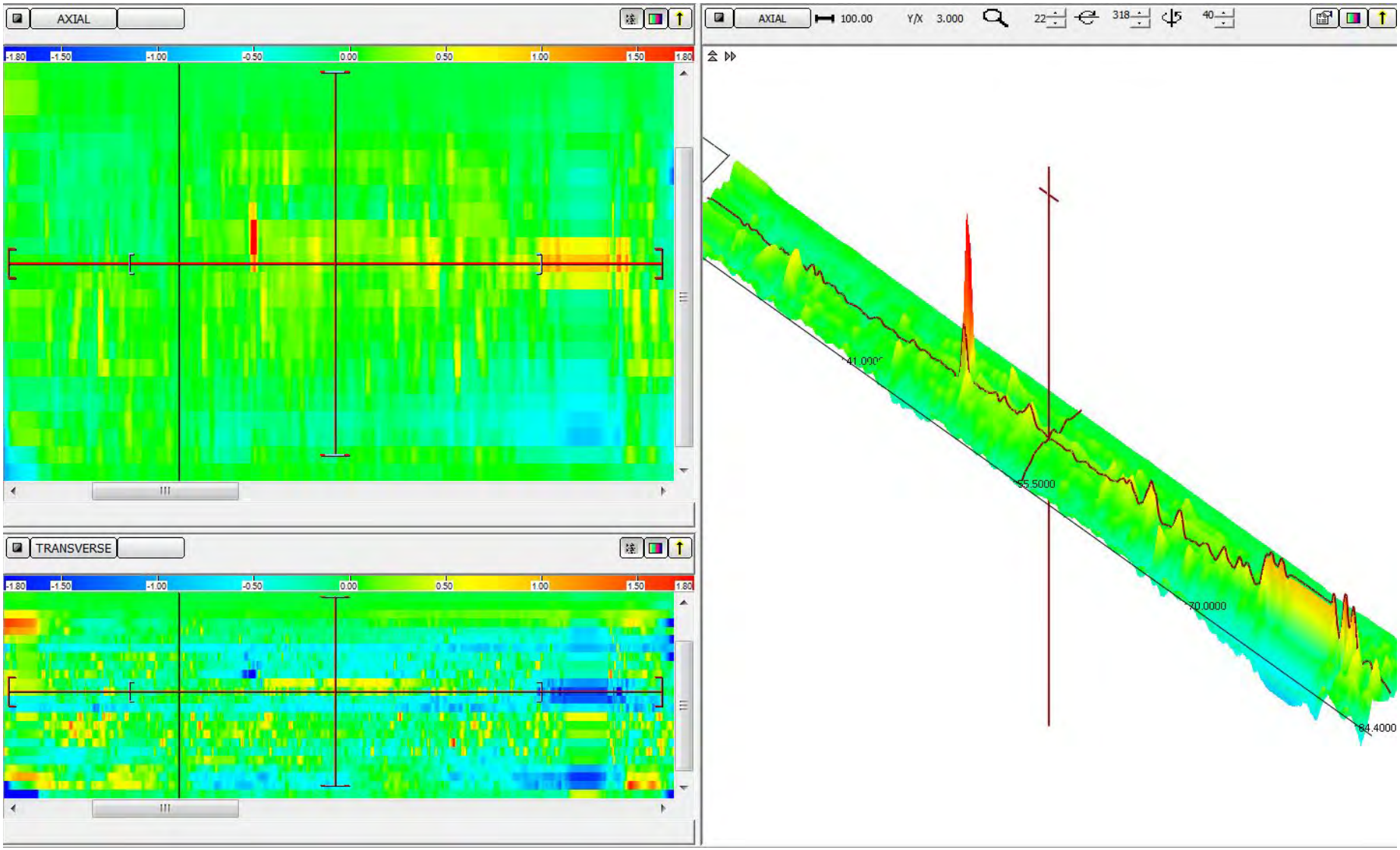
Tooth 229 A Eddy current array signal.

Tooth 223 A - minor surface breaking anomaly apparent

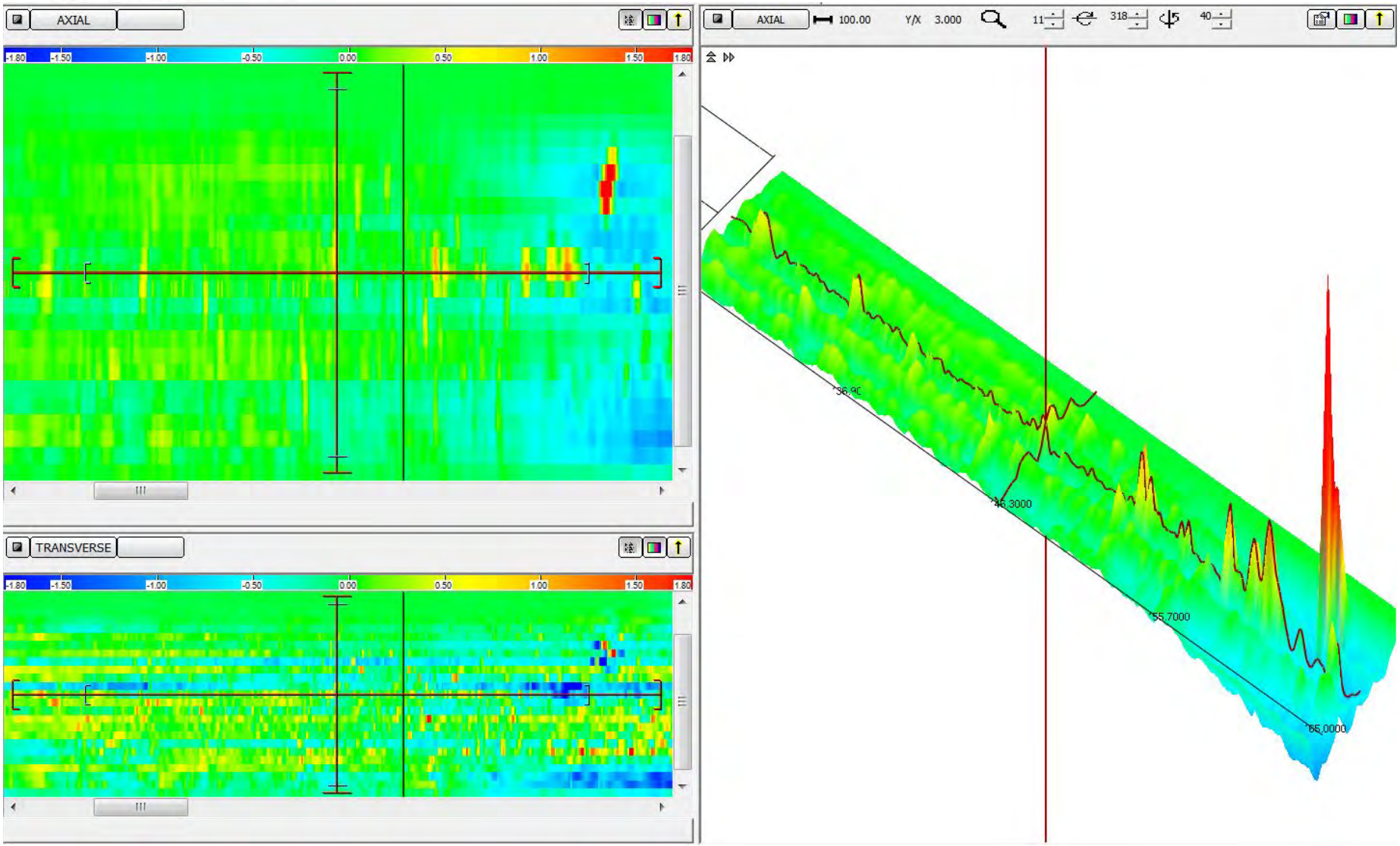


Displaying the eddy current signal for Tooth 223A

Tooth 253A highlighting the isolated anomaly.



Eddy current array image of tooth 253 A



Eddy current array image of tooth 273 A shoiwing an anomaly on the drive end . Due to the position of the mill a decent photograph was not available.

Pinion gear drive end. Note the raised pitch line.

Pinion gear Non drive end region.