TERRAFIRMA

TERRAIN MOTION INFORMATION SERVICE FOR EUROPE

MINING CASE STUDY: STOKE-ON-TRENT, UK

OVERVIEW

Stoke-on-Trent is part of a large industrial conurbation in the English Midlands (Figure 1) that is known for its pottery and china manufacturing. To the NW is the UK's largest halite field where extraction continues today. The area has an extensive history of coal mining, by partial extraction in shallow mines and total extraction in deeper mines as well as opencast workings, and as a result the area has experienced ground movement both during the extraction phase and when mine-water levels were allowed to return to normal after abandonment. Even abandoned pits that have been reclaimed and filled by waste material have experienced differential ground movement. Industrial heritage combined with ongoing phases of tectonic stressing and de-stressing have resulted in a complex ground motion history for Stoke-on-Trent. As a result, the area is ideal for the application of PSI technology for monitoring ground motion.

Figure 1: Study area.

[DEFORMATION ANALYSIS]

Persistent Scatterer Interferometry (PSI) data was analysed for 1111km^2 area centred on Stoke-on-Trent. 70 Synthetic Aperture Radar (SAR) scenes were assessed from May 1992 to February 2003. 178,019 points were identified, providing a measure of average ground movement velocity over much of the study site (Figure 2). Of these points, 68,509 (38.5%) had a full linear velocity history. Negative values of ground movement (movement away from the satellite) indicated subsidence, positive values indicated uplift.

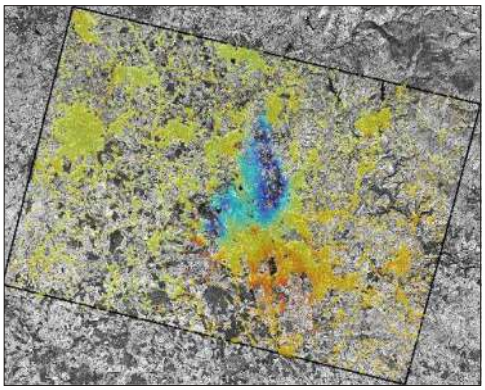

Figure 2: PS average linear velocity (blue is uplift, red is subsidence).

[VALIDATION]

The average velocity was interpolated using an inverted linear distance interpolation algorithm to enhance visualisation. The results show a large area of uplift in the north and areas of subsidence in the south-west and south-east. The average and full history PS values were compared to geo-environmental information from BGS geological maps, OS topographic maps, Intermap's NEXTMap Britain elevation data (Figure 3) and BGS-derived geology, geohazard, engineering geology and geophysical data, in order to identify potential causes of the observed ground movement.

[INTERPRETATION]

Several of the areas that experience ground motion are fault-bound or heavily fractured. In the north, uplift is observed over older undermined areas suggesting mine closure resulted in ground water recharge and elastic rebound.

Uplift also appeared to be associated with infilled quarries and waste disposal sites, possibly as a result of gas production from the decay of the site materials. In addition, there was good correlation between lower uplift rates and valley alluvium (Figure 4). Subsidence in the south showed a strong correlation with an area of recent undermining, although mine collapse and fault reactivation may be an additional cause of subsidence in this area. PSI linear velocity histories extracted at Barlaston suggest PSI data underestimates ground motion with 25mm subsidence measured by PSI compared with 130mm measured in the field by Donnelly[1] (1994) during the same period. Subsidence also showed a strong correlation with areas associated with salt extraction and dissolution (Figure 5a, b, c) and may also be a result of fault reactivation and the self-compaction and artificial loading of compressible valley alluvium.

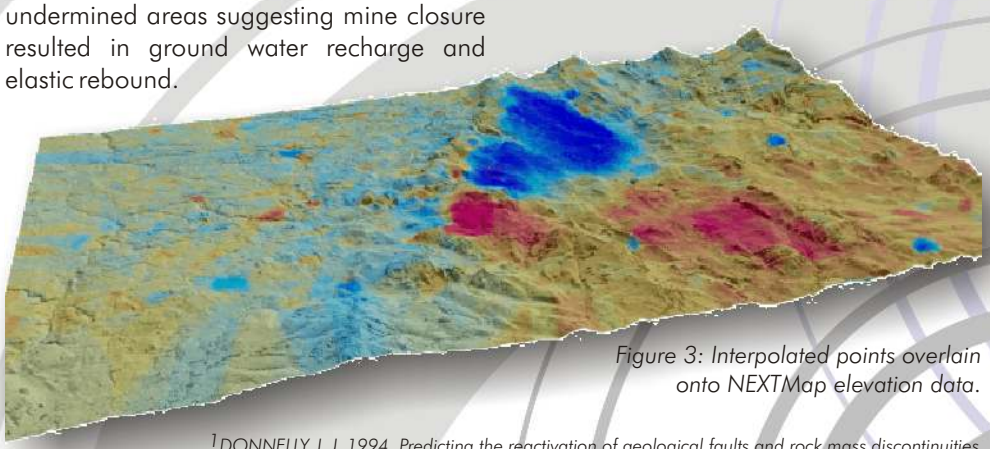

Figure 3: Interpolated points overlain onto NEXTMap elevation data.

[1] DONNELLY, L.J. 1994. *Predicting the reactivation of geological faults and rock mass discontinuities during mineral exploitation, mining subsidence and geotechnical engineering. PhD thesis (unpublished), University of Nottingham.*

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[CONCLUSIONS]

The Terrafirma product has shown that Stoke-on-Trent has experienced both subsidence and uplift between 1992 and 2004. When compared to geo-environmental information, uplift appeared to be associated with older undermining probably due to elastic rebound from groundwater recharge. Subsidence appeared to be associated with more recent undermining, areas of made ground, compressible alluvial soils and areas underlain by salt. The PSI technique appeared to identify and monitor ground movements at local and regional scale. The likely causes of ground motion were identified by comparing the data with geo-environmental information. The technique has the potential to provide information useful for environmental management.

[ACKNOWLEDGEMENTS]

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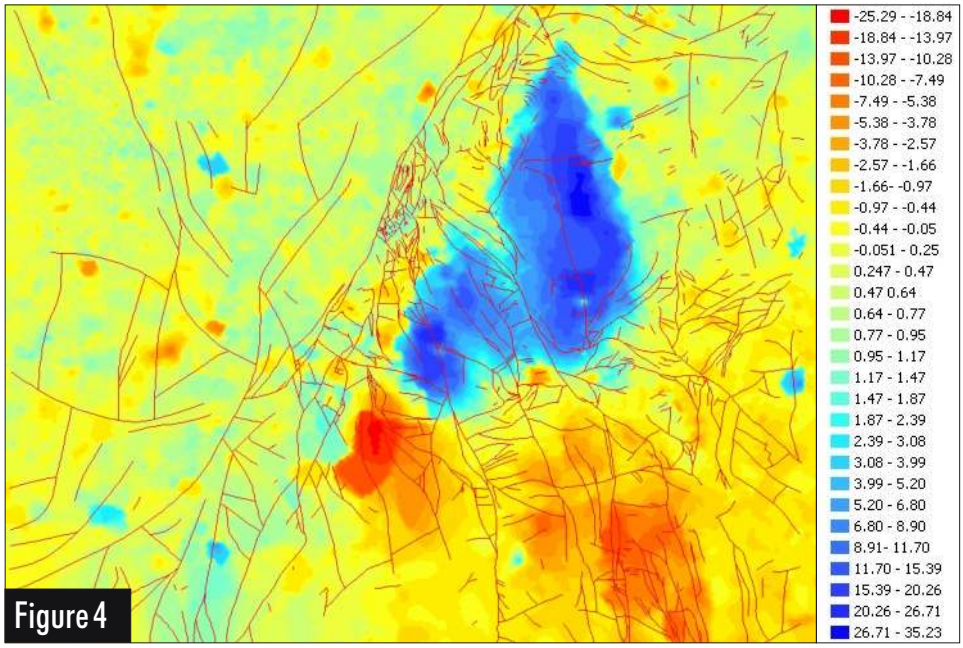

Figure 4

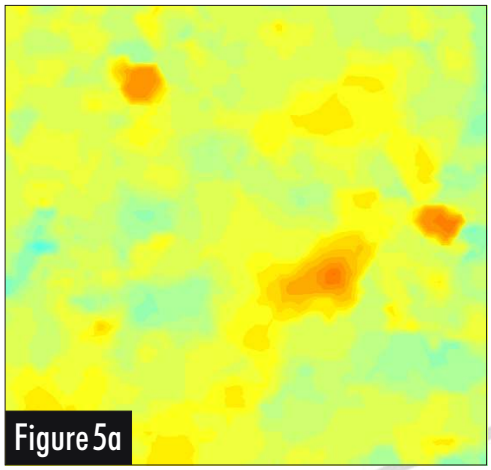
Figure 5a

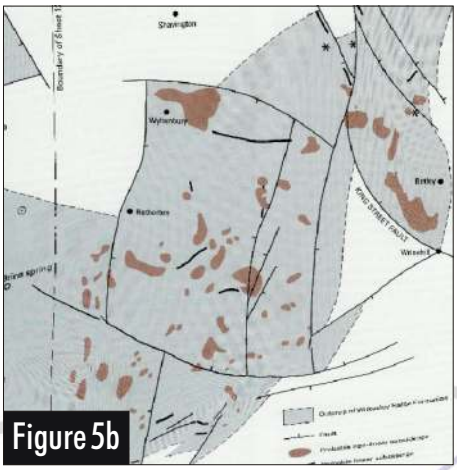
Figure 5b

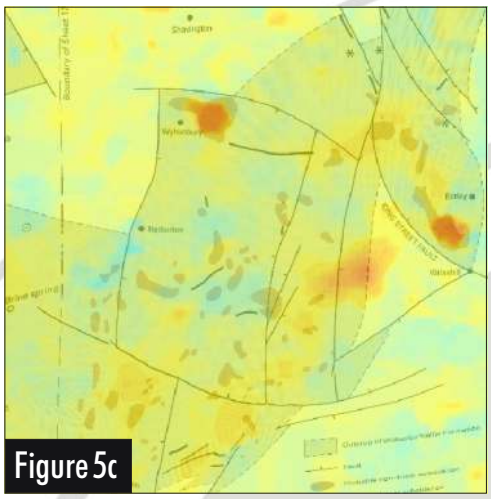
Figure 5c

Figure 4: Position of faulting and correlation of valley alluvium and lower PSI uplift rates (cyan).

Figure 5a: PSI subsidence (red).

Figure 5b: Salt dissolution (brown).

Figure 5c: Correlation between PSI and salt dissolution.

Terrafirma is one of a number of Service Element projects being run by the European Space Agency under the Global Monitoring for Environment and Security (GMES) initiative. Terrafirma is establishing a pan-European ground motion hazard information service in support of policies aimed at saving lives, improving safety and reducing economic loss. For more information on ESA initiatives on GMES, see http://earth.esa.int/gmes/ or email: info@terrafirma.eu.com. For further information www.terrafirma.eu.com