REGIONAL ARSENIC ANOMALIES SHOWN BY NURE STREAM SEDIMENT AND HYDROGEOCHEMICAL DATA IN NORTHERN WISCONSIN AND MICHIGAN

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A regional arsenic anomaly in northeastern Wisconsin and the upper peninsula of Michigan is identified in the NURE (National Uranium Resource Evaluation) surveys of stream sediments and ground water. The anomalous region is about 250 miles long in north-south direction and as much as 75 miles wide. Examination of the anomaly with regard to bedrock and glacial geologic features suggests that it is a composite anomaly caused by two different bedrock sources of arsenic and variations in glacial dispersal of arsenic-rich bedrock. The two sources differ in their expression. One, the Michigamme anomaly is expressed mostly in stream sediments and to a lesser degree in well water. The other, the Fox River Valley anomaly is expressed strongly in well water, but has almost no stream sediment signature.

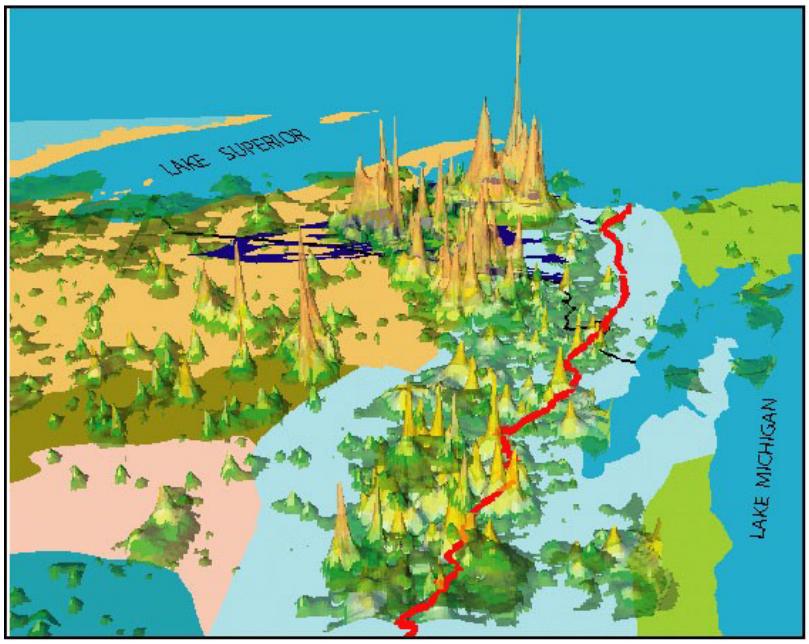

Figure 1. Composite arsenic anomaly map of northern Wisconsin and Michigan. Base is map of glacial lobes. The shaded semi-transparent surface shows a combined anomaly from both NURE stream sediment and well water data. The surface shows the more anomalous of the two data sets relative to the regional mean values of 2 ppm As for stream sediments and 0.65 ppb As for well water. Only areas with arsenic above regional mean values are shown in the 3-D surface. The surface is defined by about 3200 stream sediment analyses and 3500 well water analyses. Dark blue unit is arsenic-bearing Michigamme Formation and heavy red line is the outcrop trace of arsenic-bearing Ordovician sandstone.

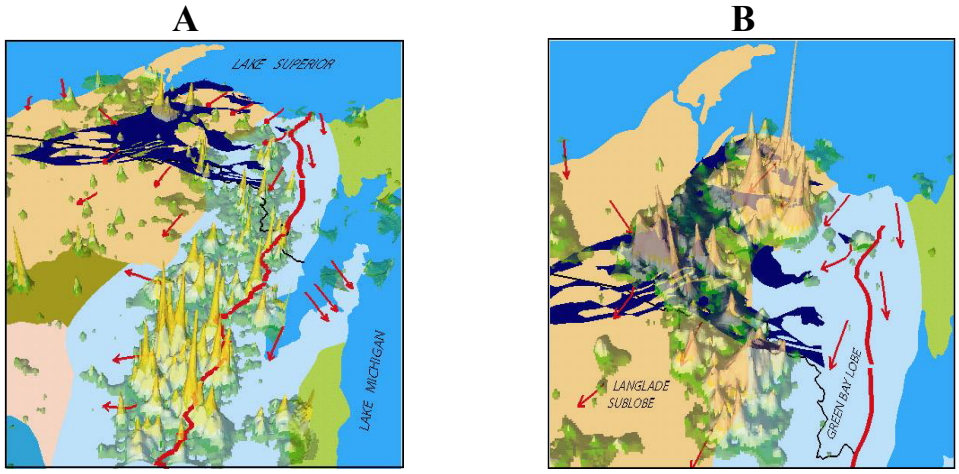

Figure 2. A. The Fox River Valley anomaly shown by well water. Anomaly lies mostly west of arsenic-rich sandstone. B. The Michigamme anomaly shown by stream sediments. Anomaly location is controlled by location of Michigamme Formation and glacial features. Base map as in Figure 1. Red arrows show direction of ice movement.

The Fox River Valley Anomaly

The Fox River Valley arsenic anomaly is best shown by NURE well water data and is only weakly expressed in stream sediment data (see Figure 2A). Arsenic values range up to a maximum of 60 ppb in well water. Interestingly, a great majority of the wells that show high arsenic in the NURE data lie west of the outcrop trace of the gently east-dipping arsenic-bearing sandstone and also west of the area where more recent data has identified an arsenic problem in wells. Bedrock in the western area of the anomaly is mostly Cambrian sandstone and Precambrian crystalline rocks, mostly granite. No arsenic source is known in these rock units. The anomaly is mostly within the area once occupied by the Green Bay glacial lobe and lies in a down-ice direction from the Ordovician sandstone. Glacial transport of arsenic-rich bedrock into the anomalous area appears to be a significant factor, suggesting that the immediate source of arsenic in well water west of the outcrop of the arsenic-rich sandstone is the unconsolidated glacial deposits.

The Michigamme Anomaly

The Michigamme anomaly is most strongly expressed in stream sediment date, but also occurs in well water data (Figure 2). It is geographically restricted by a combination of bedrock and glacial geology. The northern extent of the anomaly in stream sediments coincides very closely with the northern extent of the outcrop belt of black slate within the Precambrian Michigamme Formation. The eastern extent of the anomaly in northern Michigan is defined by the western margin of the Green Bay glacial lobe, which did not cross arsenic-rich bedrock. To the south, there appears to be glacial dispersal of arsenic-rich bedrock in both the Green Bay lobe and Langlade sublobe in northern Wisconsin where high arsenic values in stream sediments and well water extend more than 50 km south of the outcrop belt of the Michigamme black slates.

Do iron mines have an influence on arsenic redistribution?

Many iron mines in the upper peninsula of Michigan mined ores whose host rock contained pyrite-rich black slates. These mines have generated large amounts of rock waste that is potentially a source for release of arsenic as the waste material undergoes surface alteration.

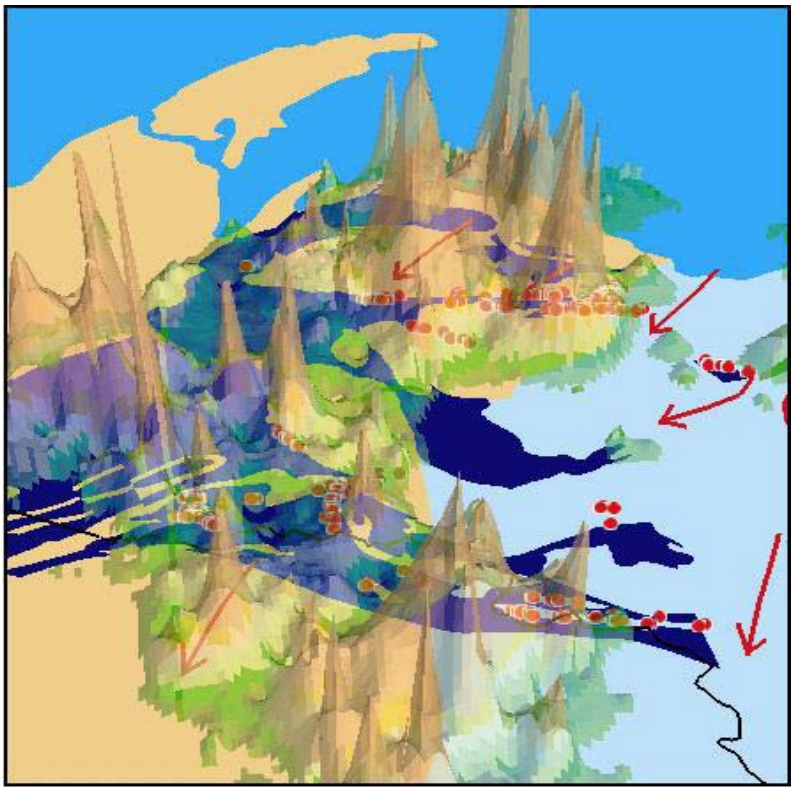

Figure 3. Map showing the location of iron mines (red dots), nearly all abandoned, within the area of the Michigamme arsenic anomaly. Dark blue unit is Michigamme Formation and other related units that contain significant amounts of pyritic black slate.

Figure 3 shows that there is a close correspondence between the location of many mines and the arsenic anomaly. That does not imply that the mines themselves are the cause of the anomaly, which is undoubtedly not the case. It does illustrate, however, that some mines potentially have redistributed arsenic-rich bedrock. The degree to which mine wastes are arsenic enriched and the potential for liberation of arsenic from them perhaps should be a consideration in managing the long-term containment of such material.