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Relationship of Lead Mineralization and Bottom Sediment Composition of Streams, Ponca-Boxley District, Arkansas

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ABSTRACT

Samples from tributaries draining known mineralized areas contain considerably more lead than those from the main stream. The unique sediments (i.e., lead rich) from the tributaries are quickly diluted in the main stream to background levels. The lead content of the sediments from the tributaries apparently is controlled by the presence of lead-rich clasts. Sorption of lead by iron oxide coating grains is more significant in the main stream because the unique clasts are diluted. The mineralization also increases zinc and cadmium levels in the sediments. The concentration of calcium is controlled largely by the presence of limestone, whereas the concentrations of Mg, Mn, Co, Cu, Cr and Ni are controlled primarily by the presence of shale fragments and sorption by iron oxide coating clasts.

INTRODUCTION

The Ponca-Boxley Mining District, in the upper part of the Buffalo River, northcentral Arkansas, is the site of significant lead and some zinc mineralization (Fig. 1). Mining in this area was intermittent from 1860 to 1920. In 1935 McKnight described the lead mineralized "run" from the upper part of Adds Creek to the vicinity of Moore Creek on the northwest side of the Buffalo River. Most of the southeast side was considered barren. The "run" is in the lower part of the Batesville Sandstone Formation immediately above the Boone Limestone Formation, both of Mississippian age. The greatest concentration of mines is in the vicinity of Adds Creek where the dominant lead ore, galena, and the less abundant zinc sulfide and zinc carbonate minerals were mined. A mill was constructed at the town of Ponca to concentrate the ore from the area.

The objectives of this study were (1) to determine the effect of the mineralization on the bottom sediment composition of the Buffalo River and its tributaries, and (2) to ascertain relationships of lead and other elements in the bottom sediments.

METHODS

Bottom sediment samples were taken in 10 selected tributaries (Fig. 1) upstream from their confluence with Buffalo River. Additionally, sediment was collected in the river above and below these points of tributary confluence, except no upstream samples for Moore and Running Creeks were collected. Two of the tributaries (Adds and Ponca) samples were obtained upstream of the town of Ponca (site of the old mill). All bottom sediment samples were collected near shore and below the water line by hand or plastic shovel to prevent metal contamination. After an initial air drying period, the samples were oven dried for 24 hr at 105°C to drive off latent moisture and then 500 grams of sediment from each sample was sieved on a nylon 95 mesh screen with a Plexiglas frame. One gram of the -95 mesh portion was treated with aqua regia for 13 hr to dissolve coatings covering the predominant quartz and chert grains, and also to dissolve sulfide and carbonate ore minerals. The sample then was filtered and diluted to 50 ml in preparation for analysis by atomic absorption spectrometry. The samples were analyzed for the following elements: Ca, Mg, Fe, Cd, Co, Cr, Cu, Ni, Mn, Pb, and Zn (Table I). In general, concentrations are within ±10% of the value.

Table I. Bottom Sediment Composition of Streams in Ponca-Boxley District

<table>
<thead>
<tr>
<th></th>
<th>Ca</th>
<th>Mg</th>
<th>Fe</th>
<th>Cd</th>
<th>Co</th>
<th>Cr</th>
<th>Cu</th>
<th>Ni</th>
<th>Mn</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample A</td>
<td>3.2</td>
<td>0.5</td>
<td>0.1</td>
<td>0.03</td>
<td>0.01</td>
<td>0.05</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Sample B</td>
<td>3.2</td>
<td>0.5</td>
<td>0.1</td>
<td>0.03</td>
<td>0.01</td>
<td>0.05</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Sample C</td>
<td>3.2</td>
<td>0.5</td>
<td>0.1</td>
<td>0.03</td>
<td>0.01</td>
<td>0.05</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Sample D</td>
<td>3.2</td>
<td>0.5</td>
<td>0.1</td>
<td>0.03</td>
<td>0.01</td>
<td>0.05</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Fe is expressed in weight percent and all other elements are expressed in ppm by weight.

Samples collected on the Buffalo River above and below tributaries are denoted by (A) and (B) respectively.

River miles are measured downstream along the Buffalo River from Smith Creek which is represented as zero miles.
DISCUSSION

A plot of Pb concentration of bottom sediment from the river and tributaries versus river miles (Fig. 2) corresponds well with reported mineralization. The tributaries on the mineralized side of the Buffalo River have significantly higher values than those on the nonmineralized side and those from the river. There are two anomalously high Pb values. One is from 3-Name Creek which is on the southeast side of the Buffalo River. The other is from Beech Creek which is on the northwest side of the river. If the mineralized zone of McKnight (1935) is extended across the watershed, Beech Creek should be part of the mineralized zone (Fig. 1). Although Whiteley Creek and the upper part of Ponca Creek (upstream from the town of Ponca) are on the northwest ("mineralized") side of the Buffalo River, they have no reported mineralization within their watershed. This is confirmed by the relatively low Pb content of their bottom sediment (Fig. 2). It is interesting to note that the Pb values at the mouth of Ponca Creek are higher than the values for either of the two samples collected upstream from the town of Ponca – Ponca Creek and Adds Creek (Table I). This finding can be interpreted as evidence of additional, unreported mineralization or more likely as contamination from the tailings pile at the old mill just upstream from the collection site.

There is no systematic variation of lead concentration of the bottom sediments along the part of the Buffalo River studied; however, many of the tributaries, whether draining a mineralized or nonmineralized area, contain greater concentrations of many of the elements as indicated by Pb in Figure 2. Perhaps the reason is that much of the material(s) rich in these elements is dissolved in the river. The fact that the tributary flow is composed of a large amount of groundwater also may explain some of the higher element concentrations in the tributary sediments. The groundwater tends to dissolve much more material than surface water but quickly precipitates material upon contact with the air, thus enriching the tributary sediments in some elements. Dilution of the unique (element-rich) sediments from the tributaries by nonunique sediments of the river takes place in an extremely short distance, especially as shown by Beech, Moore and Ponca Creeks (Table I; e.g. Fig. 2).

With the exception of Adds Creek, the tributaries which have the highest Pb values contain relatively low Fe concentrations (Table I). The reason for this phenomenon is not known; perhaps there is a subtle difference in lithology in these two areas which affects the sediments directly, or indirectly by changing groundwater composition and thus leading to concentration of elements in the sediments by precipitation.

The Fe values for sediments in the main stream and also in the tributaries show a decrease downstream. Mn, Co, Cr, Mg and Ni have trends similar to that for Fe, and Cu shows an especially well developed trend of decreasing concentrations downstream (Table I). An optical examination of the sediments indicated that shale fragments make up about 25% of the samples from the upper part of the Buffalo River and the amount of shale fragments gradually diminishes to about 10% near Ponca. The shale has two effects on sediment composition. First, the shale is rich in Fe (and other elements) in comparison with the sandstone and limestone in the area. Second, the groundwater in the area would contain Fe-leached from shale which is added to the sediments by precipitation as a ferric oxide coating on the sediments. The ferric oxide then sorbs other ions from the water. The Pb-Fe trend (dashed line) in Figure 3 indicates sorption of Pb by the ferric oxide coatings, and the anomalous values indicate the presence of lead-rich clasts. Similar trends were found for Mn, Co, Cr, Cu, Ni and Zn.

The values of Zn show little variance from the background level of about 65 ppm (Table I) except at Beech Creek which also has anomalously high Pb concentrations and at Adds and Ponca Creeks which have reported Zn mineralization. As in the case of lead, zinc values for Ponca Creek near its mouth are higher than the values at the two sites upstream and may indicate mineralization or contamination from tailings.

The Cd/Zn ratio for sediments from the lower part of the river was found to be relatively constant (8-10 ppm Cd to 1000 ppm Zn) and similar to that for ore from the area near Rush, Arkansas (Steele and Wagner, 1975). The Cd/Zn ratio for Buffalo River sediments from the Boxley-Ponca area is within the same range. However, the tributaries show a much greater range which may indicate simply homogenization of sediments with various Cd/Zn ratios by the river.
In summary, lead mineralization has a significant effect on the Pb concentration in bottom sediments of the tributaries, but concentrations are diluted quickly in the main stream. The mineralization also increases zinc and cadmium concentration. The concentration of Ca is controlled largely by the presence of limestone, and the concentrations of the other elements are controlled primarily by the presence of shale fragments and sorption by Fe oxide coated clasts.

LITERATURE CITED


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