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**Project Title: LOCATING FIRECLAYS AND SHALES NEAR ILLINOIS
POWER PLANTS FOR FLY ASH BRICKS.**

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ABSTRACT

Manufacturing high-quality bricks from fly ash requires blending with low-sulfur, non-calcareous shale and fireclay. To be economically feasible, fly-ash brick production needs to be located near power plants where the fly ash is produced and in areas where suitable shale and fireclay resources are present. In Illinois, suitable clays and shales occur primarily in Pennsylvanian-age strata, so research was concentrated around power plants located in areas underlain by these age rocks, principally in the Peoria-Meredosia area, the Danville region, and the Marion area. Three tasks were performed for this investigation to identify suitable clay and shale resources near Illinois power plants. For Task 1, interpretive maps were developed to identify economically feasible areas that occur within a 50-mile radius of the power stations and meet the criteria stating that clay resources need to be at least 50 feet thick and overlain by less than 50 feet of overburden materials. In the Peoria area, potential development areas occur northwest of the Illinois River Valley in the northeastern portion of Fulton County, the southern and western portions of Peoria County, and central Knox County. Near the Meredosia Power Station, areas for potential development include Southeastern Morgan County, Northern Brown County, Northern Pike County, and most of Schuyler County. In the Danville region, the southern half of Vermillion County and eastern Edgar County contain areas with the potential for fly-ash brick production. In the Marion study area, extensive clay/shale resources are present, and areas in eastern Williamson and Franklin counties and much of western and southern Saline County have potential for development. In Task 2, the mineralogy of clays and shales of these study areas was evaluated to determine their suitability for fly-ash brick production. In the Peoria area, high-quality clays and shales are present for development. In the Meredosia area, the quality of clays and shales varies. Some are suitable for fly-ash brick production, some need to be blended with other local shales, and some are unsuitable. Clays have historically been mined for brick production in the Danville region, but mineralogical analysis indicated the presence of carbonates and sulfides in the clays and shales. More detailed investigation needs to be completed to determine if the percentages and sizes of these minerals preclude their use in fly-ash brick production. For the Marion study area, addition of high quality material such as fireclay may be necessary, and in some cases, selective removal of pyrite-rich

material may be needed. Task 3 prepared specific economic models that can be used to explore for and locate specific clay and shale resources for these areas.

EXECUTIVE SUMMARY

Developing interpretive data maps of clay/shale resources for four different regions across central and southern Illinois has identified potential clay/shale deposits that could serve as raw materials to be blended with fly-ash from coal-fired power plants to make bricks. To avoid high transportation costs and make brick manufacturing economical, both clay/shale and fly-ash resources must be locally available to the brick manufacturer. Identification of clay/shale resources near coal-fired power plants which produce fly-ash as a by-product could help site a new brick manufacturing facility that was profitable and economically competitive. Development of a brick manufacturing industry using fly-ash can provide a host of economic benefits to the coal and brick industries including: 1) utilization of significant amounts of fly-ash now land-filled or stock-piled in ponds, 2) new business opportunities to commercially produce bricks from fly-ash, and 3) new jobs to stimulate the local and state economies.

The initial phase of this research identified shale and clay resources, suitable for brick production, within a 15 mile radius of the Edwards Power Station at Peoria, Illinois. This study was later expanded to include identification and mapping of shale resources within a 15 mile radius of the Meredosia Power Plant in Morgan County, southwest of Peoria along the Illinois River Valley. Available and published mineralogical and chemical data, as well as firing tests, indicate that many of these shale deposits would provide an excellent source of raw material for brick manufacturing. The goal of the current investigation is to continue to identify shale and clay resources associated with fly-ash producing (coal-burning) power plants in other regions of the state, as well as expand the study area for the Illinois River Valley in order to link data from the Peoria and Meredosia study sites.

This project had 3 primary tasks: 1) to locate and enter clay/shale resource data into the Illinois State Geological Survey's GIS mapping database so that interpretive maps could be produced which would help identify and locate suitable fly-ash brick clay/shale resources near existing coal-fired power plants in the Peoria-Meredosia, Danville, and Marion areas; 2) to select samples representative of these study areas for mineralogical analysis using standard X-ray diffraction procedures, to confirm that clay/shale materials are suitable for blends with fly-ash; 3) to develop economic models that will serve as a framework design that can be used to model, explore for, and locate specific clay and shale resources for these areas.

For this study more than 5000 well records from coal and petroleum test borings; water wells; and engineering, stratigraphic, and structure test borings were examined. Information collected includes well location, general lithology, topographic elevations, overburden thickness, and shale thickness. Compiled data were entered into an Excel database and subsequently imported into a GIS program in order to create interpretive

maps showing well locations and such shale resource attributes as overburden thickness and shale thickness.

Historically, mining of clay/shale resources and brick manufacturing have been part of the Illinois state economy since the 1800's. Most of the clay/shale mineral resources and manufacturing operations have been located in regions of the state where there is the presence of coal-bearing Pennsylvanian bedrock strata beneath surficial glacial deposits. In order for shale deposits to be economically feasible for mining, the deposits must be near the ground surface and generally greater than 50 feet thick. Surficial, or overburden, deposits must be relatively thin, less than 50 feet thick. Mining feasibility is also affected by cultural and environmental restrictions such as residential and industrial development, nature preserves, and wetlands.

For this project interpretive maps were developed utilizing data from various state and federal agency databases and GIS. Maps showing features that limit shale resources for mine development were prepared as well as isopach maps defining overburden and shale thickness. Areas of high potential for resource development were identified. Each of the 4 study sites had shale deposits that were geographically close to the power facility and could provide a clay/shale resource for brick manufacturing.

In addition to preparation of interpretive maps, rock core was analyzed using X-ray diffraction analysis. This information provides detailed mineralogical assessment of the resource area. In the Peoria area, high-quality clays and shales are present for development. In the Meredosia area, the quality of clays and shales varies. Some are suitable for fly-ash brick production, some need to be blended with other local shales, and some are unsuitable. Clays have historically been mined for brick production in the Danville region, but mineralogical analysis indicated the presence of carbonates and sulfides in the clays and shales. More detailed investigation needs to be completed to determine if the percentages and sizes of these minerals preclude their use in fly-ash brick production. For the Marion study area, addition of high quality material such as fireclay may be necessary, and in some cases, selective removal of pyrite-rich material may be needed.

The maps and data produced in this study will be useful in directing more detailed investigations of the study areas and can act as a guide to further investigations to identify areas with economic shale deposits. To better constrain resources in an area of interest, a site-specific study involving a detailed coring and sampling program needs to be undertaken prior to any exploration activity to determine shale reserves and quality.

OBJECTIVES

The goals of this project during the contract period were to:

1. Locate and enter clay/shale resource data into the Illinois State Geological Survey's GIS (Geographic Information System) mapping system utilizing field notes, published and unpublished reports and maps, and confidential files to determine suitable areas for fly-ash brick manufacturing near existing coal-fired power plants in the Peoria-Meredosia, Danville, and Marion areas.
2. Select samples representative of these study areas for mineralogical analysis using standard X-ray diffraction procedures developed by the Illinois State Geological Survey's Minerals and Resource Economics Section to confirm that clay/shale materials are suitable for blends with fly-ash.
3. Develop economic models that will serve as a framework design that can be used to model, explore for, and locate specific clay and shale resources for these areas.

INTRODUCTION AND BACKGROUND

Prior investigation by the ISGS, funded by the Illinois Clean Coal Institute, demonstrated the feasible use of fly-ash as an economically attractive raw material for use in commercial brick production. Coal-burning power plants in Illinois are estimated to produce about 3 million tons of fly ash per year and about the same quantity of bottom ash. Some of this material is used in cement and road construction, but landfill disposal of the remaining ash costs millions of dollars, increasing the cost of generating electricity.

ISGS research has shown that the fly ash must be mixed with clay or shale to manufacture quality bricks. Presently most brick plants are located near the clay and shale deposits that are their primary resource material. If fly-ash is used as a raw material in current brick production, the fly ash might possibly have to be transported long distances, raising costs and decreasing economic feasibility. Developing clay and shale resources near the source of fly ash at power plants can minimize transportation costs making the manufacture of fly-ash bricks economically appealing. This information has helped develop interest in building a new commercial brick manufacturing plant to be located near an existing power-generating facility, necessitating development of clay/shale resources in the same geographic vicinity.

Successful manufacture of high-quality bricks using fly-ash, requires that the fly-ash be blended with low-sulfur, non-calcareous shale and fireclay. Resources of quality clay and shale materials must be available near a fly-ash generating power station in order for a brick manufacturing operation to be profitable. Thus a preliminary ICCI funded investigation was undertaken by the ISGS to identify potential shale and fireclay resources near the Edwards Utility Power Station, a source of fly ash for brick manufacture, located along the Illinois River Valley near Peoria. That investigation was

later expanded to include mapping of shale resources near Meredosia Power Plant in Morgan County, Illinois.

The goal of the current investigation is to continue to identify shale and clay resources associated with fly-ash producing coal-burning power plants in other regions of the state, as well as expand the study area for the Illinois River Valley in order to link data from the Peoria and Meredosia study sites. Coal burning power plants near Danville and Marion, Illinois were selected as new study centers for this investigation, in addition to expanding data collection in the Illinois River Valley study area (Figure 1). Project objectives include identification of clay/shale resource sites; development of interpretive maps delineating resource availability, thickness, and distribution; generation and assessment of mineralogical data to assist in resource area identification; and development of economic models that will serve as a framework design that can be used to model, explore for, and locate specific clay and shale resources and that will aid in maximizing profitability and resource utilization.

Historically, mining of clay/shale resources and brick manufacturing have been part of the Illinois state economy since the 1800's. Most of the clay/shale mineral resources and manufacturing operations have been located in regions of the state where there is the presence of coal-bearing Pennsylvanian bedrock strata beneath surficial glacial deposits. Figure 2 shows the extent of Pennsylvanian bedrock with the location of historical clay/shale mines and clay products manufacturers as well as extant mines and production operations.

The thickness of surficial deposits is an important factor in determining whether a shale deposit is economically mineable. Glacial sediments, most of which were deposited less than 250,000 years ago, comprise the bulk of the surficial deposits in the study areas. The underlying Pennsylvanian bedrock consists of alternating layers of sandstone, underclays, coals, shales, and limestone, mostly deposited in repetitive cyclical successions called cyclothems (Wanless and Weller, 1932), which represent alternating periods of marine transgression and regression. The upper and middle Pennsylvanian is characterized by clay- and shale-rich strata, while the lower Pennsylvanian characteristically has a higher sand content. Pre-Pennsylvanian rocks generally consist of limestones and shales and often contain too much carbonate material to be suitable for brick manufacturing.

This study has identified several sites in the study areas having potential for economic shale resource development. Distribution of these resources near coal-burning power stations that generate fly-ash increases the economic feasibility for development of a profitable shale-fly ash brick manufacturing plant in these areas. If built, the new brick manufacturing industry would not only increase utilization of an otherwise unused resource, fly-ash, it would also create new jobs, benefiting the State and local economies.

RESULTS AND DISCUSSION

Task 1. Database and Mapping

Task 1 included development and production of interpretive maps that delineate potential near-surface shale resources throughout the state, particularly within the designated study areas. Study areas for this project were delineated by defining a 50-mile radius around each of the 4 principal power stations chosen for this research, Edwards Power Station at Peoria, Meredosia Power Station, Danville Power Station, and Marion Power Station (Figure 1).

Well data located within the study area were chosen based on geographic location and completeness of the well record. Data used in developing the interpretive maps for this study came primarily from ISGS well records and drilled rock core. These records contain descriptions of geologic materials penetrated by wells drilled for water, for coal and petroleum exploration, and for engineering, stratigraphic, and structural geology tests. A total of 5043 wells from the 4 study sites were examined and the data entered into an Excel database. This information included well location, general lithology, topographic elevations, overburden thickness, and shale thickness. Utilizing a computer program developed at the ISGS to calculate latitude and longitude locations for each well from its well record data, the Excel spreadsheet was then imported into a GIS program, which was used to create interpretive maps showing well locations and such shale resource attributes as overburden thickness and shale thickness.

In addition, an assortment of data from GIS information files were compiled using a variety of database resources, including the ISGS database, the Indiana Geological Survey (IGS) database, and the U.S. Geological Survey (USGS) database; these include files containing data such as state and county boundaries, bedrock geology, transportation and municipal infrastructure, abandoned and extant mine sites, brick and clay products manufacturers, mined out areas (for coal), etc. This information was combined with the well data files to construct maps showing the various attributes of the shale resources and study sites. For example, data was extracted from the well records, entered into the GIS database, and maps generated showing the location of well records with respect to transportation and municipal infrastructure. Figure 3, a map of the Peoria-Meredosia area, is an example of well data overlying infrastructure. Transportation and municipal infrastructure, for example industrial and residential development, and environmental restrictions, such as nature preserves and wetlands, can limit the availability of a shale deposit as well as provide resources to economically optimize its development.

In order for mining to be economically feasible, the mineable shale resource needs to be within 50 feet of the ground surface and needs to be suitably thick, at least 50 feet, to provide an economically profitable deposit. Depth to the top of the useable shale, or overburden thickness, is an important factor in defining areas that are suitable for mining. Overburden, as defined in this report, includes the combined thicknesses of unconsolidated surficial sediments, plus any coal, black shale, sandstone, or limestone layers present above the shale resource. Suitable resource selection criteria are a direct

function of the ratio of overburden thickness to resource thickness. For this study, shale resources greater than 50 feet in thickness underlying less than 50 feet of overburden were considered as suitable regions for resource development. To highlight these areas, contour isopach maps showing overburden thickness, shale resource thickness, shale resource thickness overlying overburden, and stratigraphy were developed. Maps for the Peoria-Meredosia area are given as examples of the interpretive maps created. Figure 4 is an isopach map defining overburden thickness in the Peoria-Meredosia study area. Yellow indicates areas where the overburden thickness is less than 50 feet, making it a possible location for shale resource selection. Isopach maps were also created to show varying shale thickness across the study site (Figure 5). Areas shown in green and blue are regions with the thickest shale deposits and are the areas with the most potential for resource development. In Figure 6, shale thickness, represented by data points, is shown overlying the overburden isopach. Red dots indicate areas where shale thickness exceeds 50 feet, making these areas potential resources of economically mineable shale. Incremented shale thickness with respect to overburden thickness was also plotted (Figure 7). Figures 8-9 are stratigraphic columns representative of the regional geology and shown by location on the overburden isopach map. Most interpretive maps for the Danville and Marion areas are included in Appendix A.

Peoria-Meredosia Study Area Shale Resources

Six coal burning power stations are located in the Illinois River Valley study area, including the Edwards and Meredosia Power Plants, the focus sites for this study (Figure 1). Well data were collected in a 50-mile radius around both power plants, linking the two areas along the Illinois River Valley. A number of areas near the Edwards and Meredosia utility sites were identified as having thin overburden with limited restrictions, making mine development economically feasible. Data from 3082 well records were collected for the Peoria-Meredosia study region. Figure 6 shows that the best resource areas (areas having less than 50 feet of overburden and greater than 50 feet of shale) in the Illinois River Valley lie on the northwest side of the Illinois River. Along the southeast side of the river, trending from the northeast to the southwest, overburden is thick making this region unsuitable for resource consideration.

Figure 4, showing overburden thickness in the Peoria region, reveals that areas to the east and south of the Edwards Power Station contain thick glacial deposits making these areas undesirable for resource development. The heavily urbanized areas in Peoria and the surrounding communities were also eliminated because of the restrictions they posed to mining. Thinner glacial drift in the regions southwest, west, and northwest of Peoria make these areas better suited for resource development consideration. The northeast portion of Fulton County, southern and western portions of Peoria County, and central Knox County are all areas within the 50-mile study radius that have less than 50 feet of overburden. Figure 6 indicates that these counties also contain well data indicating shale thicknesses of 50 feet or greater, making these areas excellent candidates for more detailed study, in order to precisely locate a mineable shale resource. These areas are underlain by Pennsylvanian age Carbondale and Modesto Formations, both of which

contain relatively thick shale beds that historically have been utilized for brick manufacture.

Meredosia Power Station is located in Morgan County, to the southwest along the Illinois River Valley from the Edwards Power Station. Data was collected from 1170 wells within a 50-mile radius of the Meredosia Power Plant encompassing all or portions of 14 counties. Figure 6 reveals that southeastern Morgan, northern Brown, northern Pike, and most of Schuyler Counties have thick shale resources underlying less than 50 feet of overburden. In this region the bedrock surface below the unconsolidated sediment includes the Pennsylvanian-age Spoon and Carbondale Formations and Mississippian and older limestones and shales. Shales from the Carbondale Formation, especially the Purington Shale, Canton Shale, and the Lawson Shale, are generally the only ones suitable as raw material for making bricks. Although thick shale layers are present in the pre-Pennsylvanian rocks, the shales are too calcareous or do not have the right firing properties for brick-making. Figure 8 shows stratigraphic columns for the Peoria-Meredosia region and are representative of optimal areas for further resource development studies.

Danville Study Area Shale Resources

The Danville study region of Eastern Illinois also includes portions of west-central Indiana. The study area is covered by Pleistocene glacial deposits (drift) that vary in thickness from a few feet to over 300 feet. In most of Vermilion and Edgar counties the drift averages around 50 feet in thickness. In areas where pre-Pleistocene valleys have been filled the drift can reach thicknesses of 200-300 feet. The glacial drift throughout this region is predominantly a highly calcareous clay or clayey silt. These glacial deposits are underlain by Pennsylvanian age rocks of the Mattoon, Bond, and Modesto Formations.

Data from 791 well records were used to create isopach maps which define overburden and shale thickness as well as delineate infrastructure and environmental restrictions that might be important in shale resource development (see Figures A1-A4 in Appendix A). The glacial drift deposits comprising the area's overburden increase in thickness in the northern and western portions of the study area making these regions less suitable for consideration as a clay/shale resource (Figure A2). The southern portion of Vermilion County and the eastern section of Edgar County have large areas where the overburden is less than 50 feet thick. Examination of the well data and shale thickness isopach (Figure A4) shows that the entire southern half of Vermilion County, just south of the Danville Power Plant and southwest of the city of Danville and its surroundings, has shale resources that meet or exceed the minimum 50 feet of thickness selection criteria. On this same map, it can also be seen that there are shale resources in eastern Edgar County that are greater than 50 feet thick. A study by White and Parham (1967) on the Pennsylvanian clays in Vermilion and Edgar Counties concluded that clays and shales in this area were suitable for use in tiles, pottery, refractories, sewer pipes, and structural clay products. The shales might also be considered for use in the manufacture of lightweight aggregate and ceramic block.

Marion Study Area Shale Resources

As with the other study sites, the Marion study area is covered with glacial deposits and underlain by Pennsylvanian rocks of the Modesto, Carbondale, and Spoon Formations. Throughout this region, rocks in the Pennsylvanian dip gently eastward, with the shales, limestones, sandstones, and coals better developed in the eastern part of the study area. Exposures of Pennsylvanian rocks are limited primarily to stream cuts, road cuts, and mines.

Extensive clay/shale resources are found throughout the Marion study site. Examination of the overburden thickness isopach (Figure A6) for this area shows large portions of the study region are covered in less than 50 feet of glacial drift. Additionally many well data show core that contain greater than 50 feet of shale or clay. The clay thickness isopachs (Figure A7) and Figure A8 show eastern Williamson and Franklin Counties and much of western and southern Saline County have clay and shale deposits that meet the minimum thickness requirement of 50 feet to be considered as a fly-ash brick clay resource.

Task 2. Mineralogical Characterization and Methods

The goal of this task was to select samples representative of the study areas for mineralogical analysis using standard X-ray diffraction procedures developed by the Illinois State Geological Survey's Minerals and Resource Economics Section to confirm that clay/shale materials within the study area are suitable for blends with fly-ash. Cores, from the ISGS archives, were selected from identified potential resource areas and a total of 40 samples collected for data analysis. Random bulk powder analyses were run on each sample in order to identify the non-clay mineral component of the clay/shale material. Oriented samples were prepared for identification of the clay mineral fraction.

The fireclays and shales in the Pennsylvanian are well suited for use as raw materials for brick manufacture. Ideally raw materials used to make bricks must contain a high enough percentage of refractory clay material, such as kaolinite, to bind with the fly-ash and maintain the shape of the ceramic body during firing, and enough lower-melting point minerals (such as feldspars, chlorite, and Fe-rich illite) to melt and form a steel-hard body having very low water absorption. Rarely does a single mineral deposit contain the right combination of minerals to produce the desired product. More commonly fireclay and/or quartz have to be added to the raw material to achieve the proper green strength for the clay body, or to control the color of the fired product. In Illinois, fireclays are commonly added to the clay/shale body to both lighten the fired color of the body and to increase the strength and fire rating. Fireclays, primarily composed of kaolinite and mixed-layered kaolinite/expandable clays, make good refractory material because of their higher melting temperature. Quartz, illite, mixed layer illite, and chlorite act as "melters" to harden the ceramic body and make it impermeable. Shales that contain abundant expandable clay minerals, such as smectite and mixed layer illite/smectite are not good for brick making. A minimum of around 50% clay minerals is generally required in the mineral composition of the brick clay/shale resource. Clay minerals provide plasticity

and green strength to the clay body. Sand and silt are needed in the mixture to help 'open' the body for quick firing. Common clay minerals found in quality brick resource clay are illite, chlorite, kaolinite, and mixed layered/expandable clays.

Non-clay minerals can often be undesirable in a brick shale resource, particularly if present in greater than a few percent of the total mineralogy. Carbonate minerals, such as calcite and dolomite, and rock fragments convert to lime upon firing and can cause "pops" in the brick after exposure to moisture. If the carbonate is very fine grained the material can have as much as 5-10% calcareous material, but if the carbonate is in the form of discrete crystals that can pop, then less than 2% is required. Sulfur bearing minerals, such as pyrite and marcasite release SO₂ upon firing and require extra expenses to control sulfur emissions.

Pre-Pennsylvanian rocks, typically Mississippian-age, underlying the Pennsylvania clays and shales, typically have an abundance of kaolinite and less of the other clay minerals. This gives them a narrower and less than optimum firing range as well as less than optimum plasticity. They also typically contain excessive amounts of calcareous minerals.

Peoria-Meredosia Study Area

Historically fireclays and shales from the Pennsylvanian have provided good raw material for use in brick manufacture. Shale resources in the Peoria-Meredosia study area exhibit the qualities needed for development of a brick-shale resource. X-ray diffraction data shows that core from the Peoria area had high amounts of clay minerals, generally between 45 and 60 percent, with good distribution between the clay mineral species and little to no carbonate or sulfide minerals. Deleterious expandable clays are present only in small amounts and the material shows a good distribution between illite, kaolinite, and chlorite.

Three of the four cores examined for the Meredosia region showed less favorable results, primarily in the proportion of clay to non-clay minerals. Core #1 had the best results averaging between 40 and 50 percent clay minerals and around 50% quartz. Deleterious minerals, such as carbonates and sulfides were not present. Cores #2 and #3 are somewhat low in clay mineral content, but again contain little to no carbonates or sulfides. Raw material from these areas can be blended with other local shales to improve the clay to non-clay ratio and provide a good raw material for brick manufacturing. Core #4 contains high amounts of dolomite and pyrite making material from this area unsuitable as a shale/clay resource.

Danville Study Area

Core samples from the Danville Study Area indicate that this area has shales and clays that would provide a good resource for development of a brick manufacturing operation. Historically clays have been mined in this region for use in brick production. Both cores have clay mineral percentages averaging 50% or higher with the balance primarily

quartz. Core #1 has both carbonates and sulfides present. Total percent carbonate for the entire core is approximately 4%. Detailed study of this area could be done to determine the particle size of the carbonate minerals. The total percent value for sulfide minerals is around 1%, which should still be within the range of acceptability. Although expandable clays are present, their contribution is nominal. Core #2 contains greater than 50% clay and has a good distribution of clay minerals species. The amount of carbonate is high and further study would be needed to assess the particle size and distribution of the carbonate minerals.

Marion Study Area

Shale resources in the Marion Study Area have good properties for use in fly-ash brick manufacturing. Core #1 has a lower than desired clay to non-clay mineral ratio, but can be beneficiated by adding a higher quality material such as a fireclay. Carbonate and sulfide minerals are not present, making this material a desired resource. Core #2 has better clay to non-clay mineral ratio and like Core #1 contains almost no carbonate or sulfide minerals. Pyrite is present around 60 feet deep. This layer could be selectively removed in order to minimize SO₂ problems in the firing process.

Task 3. Economics Modeling: Factors that will determine the extent of fly ash utilization for brick manufacture in Illinois

Although Illinois' clay production has declined substantially in the past two decades, the remaining clay mining and processing industries are in favorable geographic locations with respect to each other as well as the coal burning power plants that may be a source of fly ash for brick production in the future.

The clay pits in Illinois are located in the counties of La Salle and Livingston in the north, McDonough in the west, Bond in the south central region and Pulaski in the south. Plants that produce clay products, such as bricks and tiles, are distributed over 11 counties in an approximate arch from the Lake and Cook counties in the north-east to Warren and McDonough in the west, and going south to Scott, Madison and Pulaski counties. Similarly, most of the coal burning power plants also are located in a parallel arch of counties, with only a few power plants located outside this arch, in the counties of Vermilion, Jasper and Crawford on the eastern side of the state.

The geographic distribution puts Illinois' clay pits, clay products plants and at least one coal burning power plant within about 50 miles of each other. In spite of the favorable geography, many power plants are not close to clay pits or clay products plants. Especially in the eastern region of the downstate area, efforts to find clay deposits could pay rich dividends in the future because fly ash would be readily available from power plants in that area.

Transportation of clay and fly ash will likely depend on trucking. However, the markets for the finished clay products - bricks and tiles - is more likely to be in areas of denser population such as north-east Illinois and the down-state metro areas. Therefore,

alternative modes of transportation – rail and barge – should be studied for cost comparison.

The future situation in the electric power generation industry may differ considerably from the current situation, however, because of economic compulsions. The need to reduce overall transportation costs for coal and limestone, and to make Illinois coal more competitive, will result in more power plants being built at or near future coal mines. There are no coal mines in the deepest part of the Illinois Basin anymore. There are sixteen coal mines currently operating in Illinois, 4 surface mines and 12 underground mines. Ten of the mines – 4 Surface and 6 Underground – are located in the southern semi circular region comprising the counties of Randolph, Perry, Jackson, Williamson, Saline, White and Wabash. The other 6 mines are in Macoupin, Logan and Vermilion counties. The coal mines that continue to operate in Illinois need to remain cost competitive. Depth of mining is only one of the factors influencing costs. Equally important, perhaps more so, are the geologic and tectonic conditions in coal fields. From the perspective of the clay and fly ash industries, it is, therefore, necessary to watch the developments in the coal industry to assess where future mines, and therefore future power plants, will be located.

Fly ash, clay, coal and limestone are all bulk materials with relatively modest unit value. Their market prospects, therefore, can be negatively affected if transportation adds to their ultimate price to users. The transportation cost factor should serve as a point of common interest to all these industries. Collaboration at corporate levels in these industries would offer an opportunity to form joint ventures in which mining of coal, clay and limestone, generation of electric power and utilization of fly ash, and perhaps gypsum byproduct, would form a single complex. Such complexes would offer synergies that reduce overall costs to all participants and create economic activity, including jobs, in rural areas of Illinois.

CONCLUSIONS AND RECOMMENDATIONS

Historically shales in the Pennsylvanian have been mined for use in brick manufacturing. The Pennsylvanian age Carbondale and Modesto Formations provide some of the highest quality materials and are present in our study areas. These units will make good resources for the development of brick manufacturing in the Illinois River Valley. Extensive resources exist throughout the Peoria-Meredosia study site; areas with shale resources greater than 50 feet thick, relatively thin overburden, and minimal resource development restrictions. The best resource areas in the Illinois River Valley lie on the northwest side of the Illinois River. Along the southeast side of the river, trending from the northeast to the southwest, overburden is thick making this region unsuitable for resource consideration. In the northern portion of the Illinois River Valley, near the Edward Power Station, areas with the highest potential for resource development include the northeast portion of Fulton County, southern and western portions of Peoria County, and central Knox County. Mineralogical data suggests that high-quality clays and shales are present for development. In the southern portion of the Illinois River Valley near

Meredosia Power Station, areas for potential resource development include southeastern Morgan County, northern Brown County, northern Pike County, and most of Schuyler County. The quality of the clays and shales is more variable in the Meredosia area, some are suitable for fly-ash brick production, some need to be blended with other local shales, and some are unsuitable due to low percent clay minerals and/or high values of carbonates and sulfides.

Overburden is thick in many areas around the Danville Power Plant, but good shale resources are available in the southern half of Vermilion County and eastern Edgar County. Mineralogical analysis of core in this region indicates the presence of deleterious carbonate and sulfide minerals in the clays and shales. Selective mining and good data control can help minimize the negative effects of these minerals on brick production.

The Marion Study Area has thin overburden and thick shale resources. Mineralogical assessment indicates that the ratio of clay to nonclay minerals is variable and the addition of high quality material, such as a fireclay, may be necessary to obtain the needed clay mineral composition for use in making fly-ash brick. Areas in eastern Williamson and Franklin Counties and much of western and southern Saline County have potential for development.

More extensive mineralogical analysis in selected resource sites could provide better data control and allow for the development of interpretive maps that could delineate optimal fly-ash brick clay/shale resource areas. Because the available well data are not sufficient to provide site-specific details, these maps should be used only as a general guide for selecting areas where further investigation is likely to produce favorable results. Once a location has been selected for further study, a detailed exploratory program that consists of core drilling and sampling is needed to assess shale thickness and depth and to evaluate mineralogical and physical properties of the shale to be used for brick. Such study must precede land acquisition for potential siting of a new pit to assure that an adequate quantity of suitable shale is available for the potential brick plant.

It should be noted that the well records used for this study were provided by a variety of sources including drilling companies and the quality of the information provided varies considerably. The majority of the records are probably accurate, especially those from coal and petroleum test borings. In addition, there could be problems with the accuracy of well locations for some drill holes used for this study, especially water wells. Verification of well locations can be done, once a specific location has been decided by the interested parties for further investigation.

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EQUIPMENT INVENTORY REPORT
September 1, 2003, through August 31, 2004

Project Title: **LOCATION FIRECLAYS AND SHALES NEAR ILLINOIS
POWER PLANTS FOR FLY ASH BRICKS**

ICCI Project Number: 03-1/6.1E-1
Principal Investigator: Zakaria Lasemi, Illinois State Geological Survey (ISGS)
Other Investigators: Karan S. Keith, Subhash B. Bhagwat, Christopher
Majerczyk, Lisa R. Smith, Hannes E. Leetaru, Randall
Hughes, Adam Barnett, Mei-In Chou, ISGS
Project Manager: Dr. Francois Botha, ICCI

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List of Publications and Presentations

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Weibel, C. P., and Z. Lasemi. 2003. "Shale Resources of the Peoria and Meredosia Areas." Preliminary mapping results presented at a meeting attended by the members of brick and power plant industry and representatives from ICCI, DCEO and ISGS, November 13, 2003, Chicago.

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APPENDIX A

CLAY/SHALE RESOURCE INTERPRETIVE MAPS

APPENDIX B

MINERALOGICAL ANALYSIS DATA