

# North Carolina Mining and Energy Commission

Administration of Oil and Gas Committee

and the

Environmental Standards Committee

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## Diabase Dikes and Sills – Are There Concerns Associated With These Geologic Features in Shale Gas Exploration and Development?



presented by

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# Background

A) What is **diabase** and what are **dikes** and **sills**?

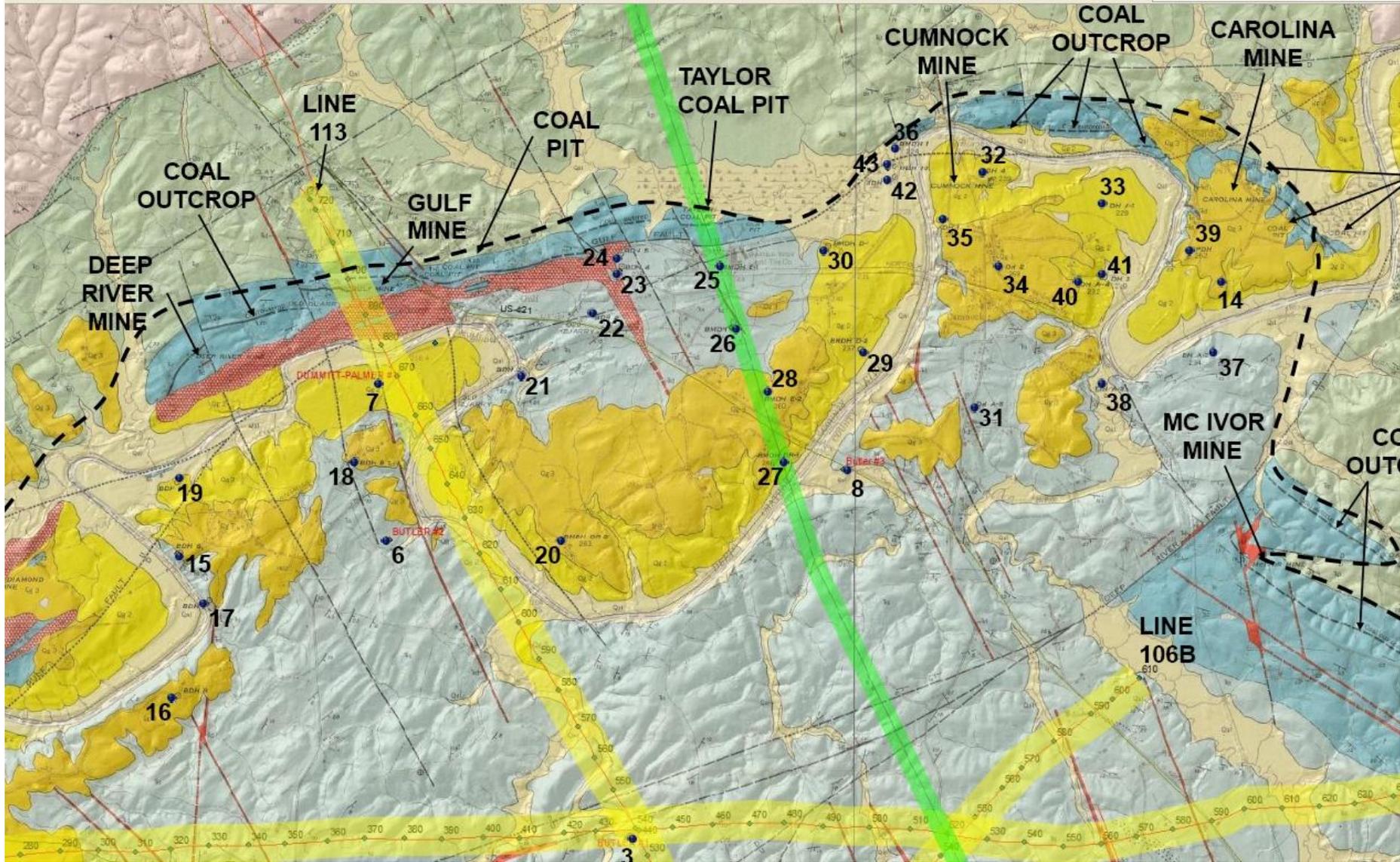
- Diabase is a plutonic (intrusive) igneous rock which is composed of interlocking minerals crystallized from molten rock (magma).

- Diabase is enriched in magnesium and iron and crystallizes dark minerals and is called mafic (*ma* from magnesium and *f* from ferric [iron]).

- Diabase is a term used to describe finer-grained gabbro that commonly occurs in small, shallow intrusives.

# Background (continued 2)

- Dikes and sills are intrusives. When magma rises in the crust, the near vertical tabular bodies are called dikes and the nearly horizontal bodies are called sills. Dikes cut through sedimentary bedding while sills intrude parallel to bedding.
- Diabase dikes and sills are associated with CAMP (**C**entral **A**tlantic **M**agmatic **P**rovince) and have been age dated to the early Jurassic (200 million years ago) when the supercontinent of Pangea was breaking up.



# Background (continued 3)

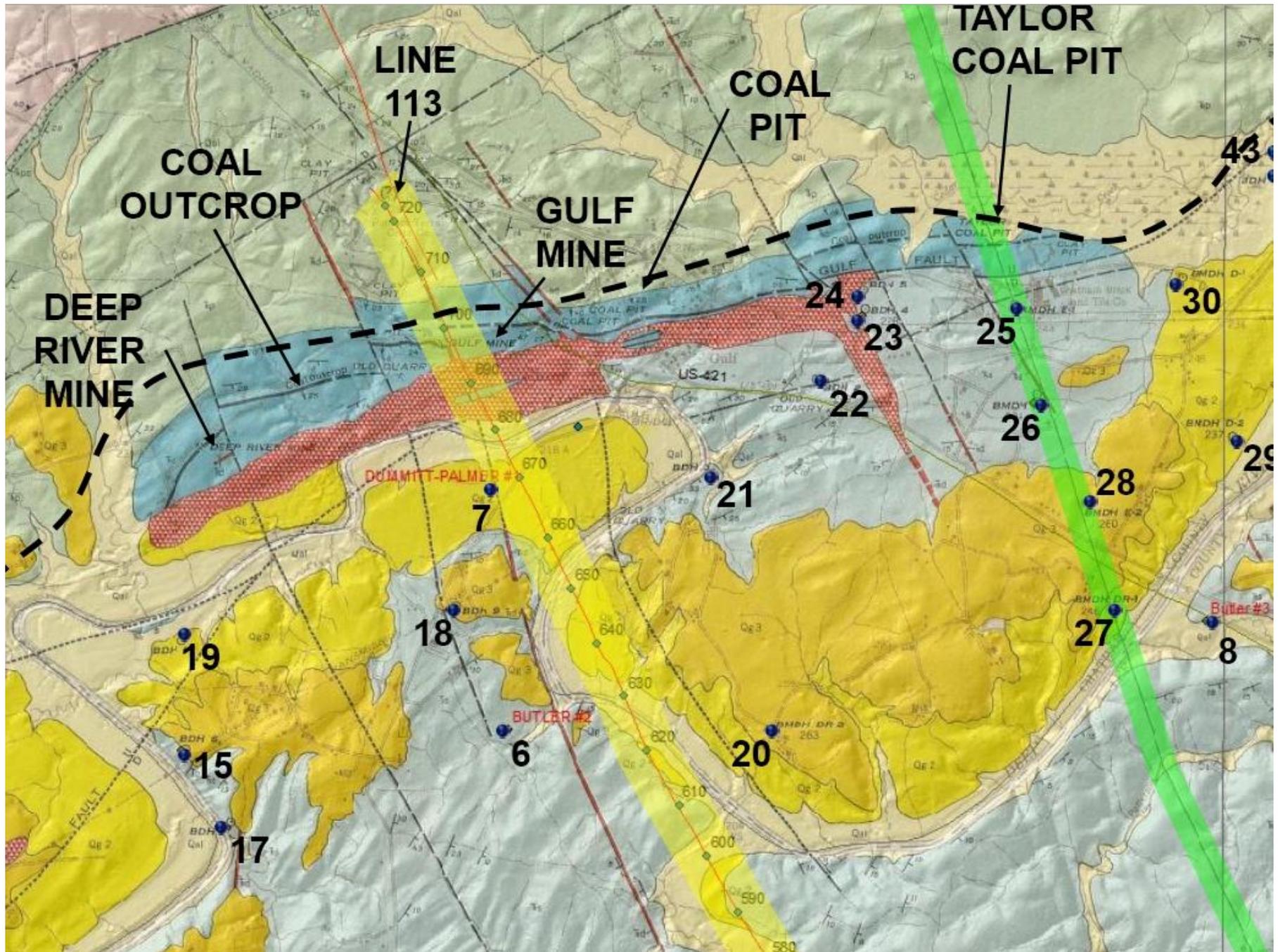
B) How extensive are these intrusives?

- From detailed geologic mapping, the sills are located in the Cumnock Formation. The heat from the intrusives metamorphosed the Cumnock Formation's coal beds to semi-anthracite, anthracite, and coke.
- Intrusive temperatures range from 1200° F (650° C) to 750° F (400° C).
- “Baked zone” extends about one-half of the width or thickness of the dike or sill into the country rock.

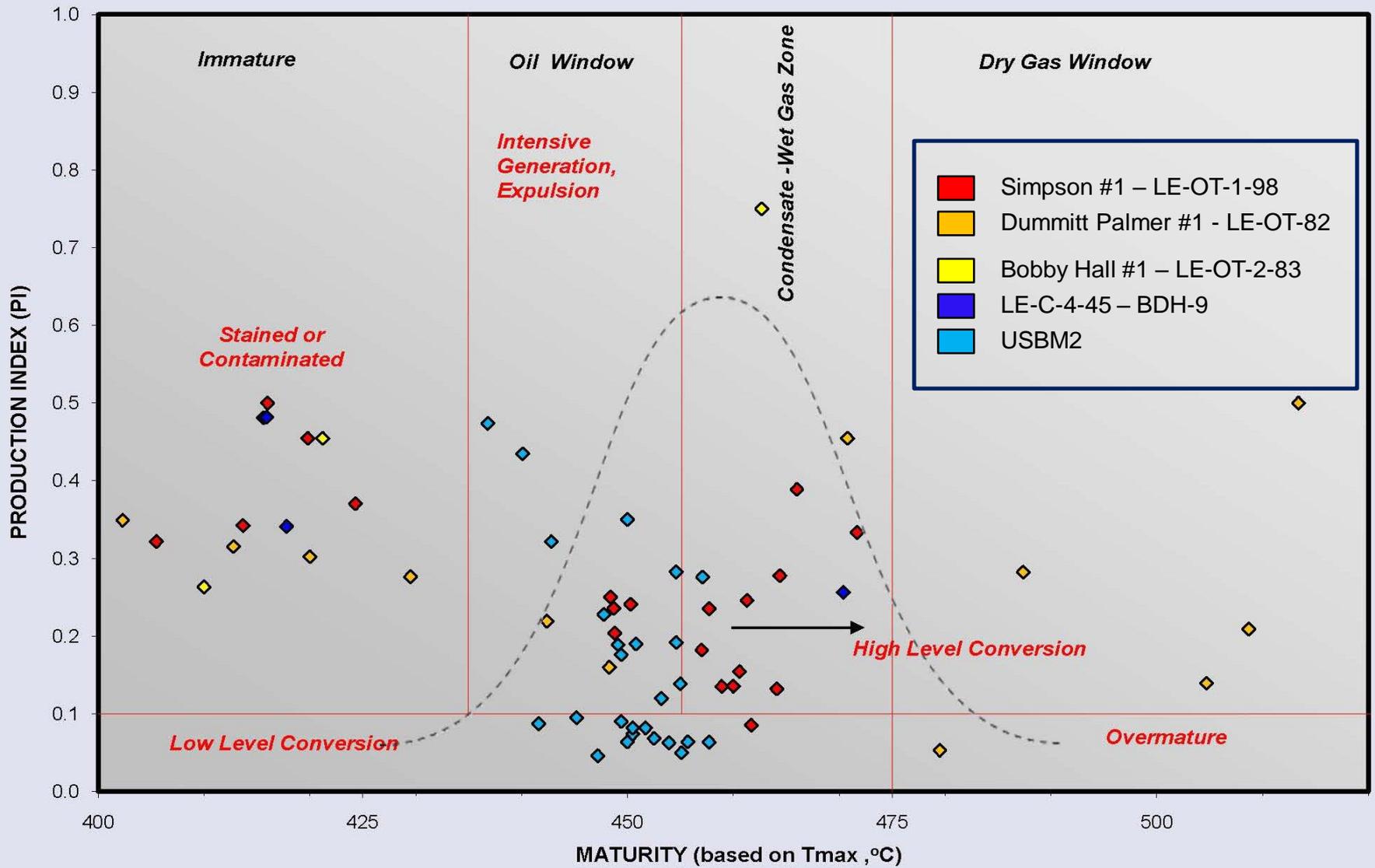
## Background (continued 4)

C) What does that do to the potential gas/oil resource?

- In at least one drill hole (Dummitt Palmer #1), a coal bed methane test hole, about 40,000 mcf of gas emanated from one of the fractured diabase dikes penetrated by this drill hole.
- Thermal maturity analyses show samples from the Dummitt Palmer #1 well to range from immature, oil window, “wet gas”, dry gas, to over mature.



# Kerogen type and maturity (Tmax) – multiple wells



# What are some of the questions concerning diabase dikes and sills?

- Q-1: Would companies “target” the dikes and drill laterals close to those intrusives?
- A-1: It is unclear why a company would do that since data from Butler #3 (not near an intrusive has 890 psi pressure holding since drilled in 1998).
- Q-2: The sills in the northwest margin of the Sanford sub-basin have consumed the Cumnock Formation. Is that the case throughout the basin?
- A-2: No, extensive underground mapping in the coal fields shows the sills do not go deeper into the basin.

## Questions (continued 2)

- Q-3: Are the dikes and sills conduits for the movement of oil, condensates and/or gas?
- A-3: Fracture closure depths were determined as a design criteria to define competent rock as part of the Sharon Harris NPP. Results build on similar geotechnical studies at the adjacent parcel for the low level radioactive waste (LLRW) repository.

The shallow surface aquifer has many interconnected fractures. However, *“these fractures are common to depths of 100 feet below ground surface..., but become less prevalent with increased depth.”*

## Questions (continued 3)

- A-3 (continued) *At depths greater than 400 feet, the fractures are closed and sealed to water flow”*

[Sharon Harris Final Safety Analysis report, Section 2.5-56, (U.S. Nuclear Regulatory Commission, accessed on September 12, 2012)]. Fractures and joint distribution and characteristics were studied for the Sharon Harris and geotechnical investigation (section 2.5-113) and the preceding LLRW geotechnical investigation. (Section 2.5-114). Shear wave velocities were a design criterion as a proxy to define competent rock.

# Questions (continued 4)

- Q-4: Do other shale gas states have issues with diabase dikes and sills?
- A-4: The diabase dikes and sills in Pennsylvania are not in the Marcellus – they are located further east in the Gettysburg and Newark Basins. The Newark Basin was one of the five basins evaluated by the USGS in 2012. The Taylorsville and Richmond Basins in Virginia were also assessed, but there is no known exploration efforts in those basins at this time.

# Questions (continued 5)

- Q-5: The NC DENR Report mentions water being found in diabase dikes. How is that possible?
- A-5: Diabase dikes and sills weather faster than igneous rock composed of more stable minerals. Fractures in the dikes allows rainfall to accumulate in the diabase rock cracks and can create tabular bodies of shallow groundwater. Pump tests conducted for the LLRW project show the amount of water stored in these bodies can be significant source of groundwater but it can be rapidly depleted since the recharge is only rainfall.

# Summary and conclusions

- Diabase dikes and sills are part of the existing Triassic Basins in North Carolina.
- Detailed geologic mapping has shown the locations of these features.
- Aeromagnetic and ground geophysical methods can identify diabase dikes and sills.