PROPRIETARY

CALIFORNIA ENERGY COMPANY INC.

SECONDARY MINERALOGY OF HOLE CE-NB-4

NEWBERRY PROSPECT

DESCHUTES COUNTY, OREGON

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by

Columbia Geoscience

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CE-NB-4 SUMMARY OF REVIEW

Core recovered from hole CE-NB-4 between 1426 and 3715 feet has been reviewed for secondary minerals. Three general hydrologic regimes are identified through the secondary mineralogy. The first and uppermost is a zone dominated by cool meteoric water percolating downward. The secondary minerals are most readily explained by increased oxygen activity introduced with the meteoric water, and by the changing chemical solubilities resulting from the meteoric water very slowly warmed by thermal energy transfer from the host rock to the water. The second hydrologic regime is characterized by rock saturated with water of low oxygen activity. The secondary minerals suggest that the water is both chemically and thermally near to equilibrium with the host rock. These minerals typically overprint secondary minerals observed in the first hydrolic regime. The third hydrologic regime is characterized by warmer fluid moving latterally to upward, transfering thermal energy to the host rock. The secondary minerals are characteristic of water with low oxygen activity which is out of thermal equilibrium with the host rock.

In hole CE-NB-4 the boundary between the first and second zones is gradual rather than abrupt. The change appears to occur near the 2000 foot depth. Above 2000 feet the thermal gradient will probably be somewhat depressed due to heat transfering from the host rock to downward percolating fluid. Zone 2, between about 2000 feet and 3550 feet, the secondary minerals suggest a near chemical and thermal equilibrium between the water and host rock. This zone will likely show a conductive gradient. Zone 3, from 3550 to 3715 feet (the end of reviewed core), the secondary minerals are effected strongly by low temperature geothermal fluids.

From the secondary minerals observed in the core of CE-NB-4, the following can be concluded:

1. A geothermal system is currently active in the general region of hole CE-NB-4.

2. The conductive gradient between 2000 and 3550 ft. is reflective of the fluid temperatures between 3550 and 3715 feet only. This gradient should not be extrapolated to greater depth without temperature data from a conductive regime below this goethermal fluid zone.

0-1426 ft. Logged by Paul Brophy.

Beginning at 1426 ft. (box 98).
Ending at 3715 ft.

1426-1500 ft.

Gray to dark gray, variably vesicular, olivine bearing plagioclase porphyritic basaltic andesite. Small anhedral phenocrysts are scarce. Locally (i.e. at 1435 ft. and 1465 ft.), the rock contains cm-sized silicic lithic inclusions. The rock is very fresh with no obvious secondary mineralization other than sparse secondary hematite. The rock is very fractured to 1433 ft., at 1458-1465 ft., and at 1478-1495 ft.

1502-1529 ft.

Gray, dense to microvesicular, olivine bearing, plagioclase porphyritic andesite. The plagioclase phenocrysts, up to 2.8 mm in size, are very abundant in the rock. They are anhedral, rounded to subrounded, and appear to have undergone partial resorption in the melt. The brecciated, very glassy, boundaries at 1502-1503 ft. and 1528-1529 ft. show a marked decrease in phenocryst population and also contain more silicic lithic fragments; this may be a subvolcanic feature. Minor reddish hematite alteration occurs along some of the fractures and in some of the vesicles.

1529-1551 ft.

Gray to light gray, strongly brecciated, vesicular basaltic andesite. Hematite alteration is irregularly distributed throughout the rock. A reddish scoriaceous zone occurs at 1550-1551 ft.

1551-1568 ft.

Gray, sparsely porphyritic, basaltic andesite to andesite. The top 3 ft. is strongly vesicular. Minor secondary reddish hematite alteration occurs occasionally in the groundmass and along a few of the fractures. The rock shows a strong vertical fracture component and is generally strongly broken.

1568-1578 ft.

Orange devitrified (including palagonite ?) basaltic tuff with occasional scoria fragments up to 4 cm across. Secondary minerals appear to be limited to devitrification and Fe oxidizing processes.

1578-1601 ft.

Gray to dark gray, variably vesicular, highly fractured andesite (?). With sparse sub-cm plagioclase phenocrysts. Very minor secondary reddish hematite alteration is usually associated with vesicles. Fracturing appears to be related to both flow texture and tectonic movement.

1601-1611 ft.

Orange to red-gray devitrified basaltic tephra ranging from devitrified ash to lapilli scoria fragments up to 6 cm long.

Secondary mineralization appears to be limited to devitrification and iron oxidation.

1611-1649 ft.

Gray, vesicular, plagioclase porphyritic basaltic andesite to andesite. The rock is strongly broken with most fragments smaller than 4 cm, and only a few fragments exceeding 10 cm. The glassy groundmass is predominantly quite fresh. The vesicle and fracture surfaces show little evidence of secondary mineralization other than local very minor secondary hematite.

1649-1656.5 ft.

Gray to red-gray scoria.

1656.5-1687 ft.

Note: At 1687 ft. the rock grades to a more dense volcanic rock.

Gray, vesicular to scoriaceous, fresh glassy basaltic andesite. Secondary mineralization is limited to secondary red hematite, most common in the scoriaceous and strongly vesicular areas.

1687-1710 ft.

Grading to gray, very finely vesicular basaltic andesite with minor red hematite distributed throughout the rock. Note: At 1702-1710 ft. the fracture linings contain increased hydrous iron oxidation.

1710-1718 ft.

1710-1714 ft. Red-gray scoria to scoriaceos basalt-andesite, grading to scoriaceous to highly vesicular basalt-andesite at 1714-1718 ft.

1718-1730 ft.

Locally vesicular basalt-andesite. Secondary minerals are limited to minor finely disseminated red hematite, hydrous iron oxidation along fracture surfaces and minor botryoidal calcite in a few of the vesicles. The rock is strongly fractured as though it may have undergone shearing.

1730-1732.5 ft.

Sub-cm to cm-sized volcanic fragments.

1732.5-1757 ft.

Basaltic autobreccia or agglutinate.

1732.5-1740 ft. The rock tends to be more massive with large vesicles. Minor but ubiquitous hematite is observed.

below 1740 ft. More pronounce agglutinate texture with fragments of dense rock and scoria rock welded together. The rock is very fresh and shows no obvious secondary alteration.

1757-1758.5

Poorly consolidated fresh glassy black scoria.

1758.5-1852 ft.

A gray slightly porphyritic basaltic andesite. Minor mm-sized vesicles are common throughout, with local more intense zones of vesiculation. The rock contains highly fractured and sheared zones, i.e. at 1820-1827 ft. and 1839-1846 ft. Many of the fracture surfaces are coated with a fine soft patina resulting from shearing. Secondary orange to red hematite alteration is common though not ubiquitous along fracture surfaces. Occasional fracture surfaces contain clusters of acicular zeolite.

1853-1855 ft.

Gray to orange-gray scoriaceous basal welded breccia (?). Secondary reddish hematite alteration is common.

1855-1884 ft.

Scoriaceous to strongly vesicular basaltic andesite. Rock is fresh, very glassy, and has minor plagioclase phenocrysts. Minor red hematite alteration occurs around some of the vesicle walls near the top of the unit. An orange clay-like alteration of the glass is present in the basal 2 ft. of this unit.

1884-1896 ft.

Orange to gray palagonitic basaltic tephra with occasonal scoria bombs. The scoria bombs are fresh. The glass particles appear devitrified. The scoria content increases in the bottom 3 ft.

-grading to-

1896-1899 ft.

Poorly consolidated black scoria.

-grading to-

1899-1928 ft.

Variably consolidated scoria and dense bombs. The rock is predominately fresh with minor red hematite alteration along vesicle walls.

1928-1944 ft.

Scoriaceous basaltic tephra with local ash-rich zones. The rock ranges from poorly consolidated to locally welded. The only obvious secondary alteration is the red hematite.

1944-1957 ft.

Gray vesicular basalt/andesite. The flow banding suggested by the vesicle pattern is oblique (45 deg). The rock appears quite fresh except for secondary hematite alteration.

1957-1996 ft.

Red to dark gray, poorly consolidated to locally welded scoria with a variable ash component. The color grades from red to gray between 1980-1985 ft.

1996-2123 ft.

Intercalated dark red-gray to dark gray, locally welded scoria and dark gray variably vesicular basaltic andesite. The denser

portions are usually less than 10 feet thick. Minor red hematite alteration is ubiquitous, becoming more extensive in some of the scoriaceous zones. Fractures in the denser rock show minor coatings of a soft orange-to-yellow clay or colloid. Below 2020 ft. most vesicles are coated with a thin (sub-mm) light blue-gray coating. Minor white botryoidal calcite clusters, usually sub-mm, occur on a few of the vesicle walls, along with minor transculent light brown clay.

2123-2243 ft.

Light gray to gray pyroxene plagioclase porphyritic dacite. Dense glassy brecciated top and bottom boundaries suggest that this dacite may be a sub-volcanic feature. The rock is strongly fractured at 2170-2235 ft. The fractures have slickenside surfaces. Between 2210-2235 ft. orange Fe alteration is commonly associated with the fracture surfaces.

2243-2247 ft.

Welded breccia in contact with the basal section of the dacite. Some very minor Fe oxidation has occurred along fracture surfaces. The rock grades into a highly fractured zone of dark gray vesiculated andesite/basalt.

2247-2282 ft.

Dark gray, glassy, generally microvesicular andesite/basalt. The rock is strongly fractured with most of the fractures showing a thin very black slickenside coating. Occasional fractures show an additional blue-gray clay coating.

2282-2337 ft.

Dark gray, variably vesicular, generally fresh, glassy andesite/basalt. The upper 3 ft. tend to be scoriaceous and have undergone strong hematite alteration. Minor red hematite alteration of mafic groundmass crystals is common. The majority of the vesicle walls are generally fresh with no apparent alteration, though occasionally a few of them are covered with a thin light blue-gray clay. Vertical to oblique tectonic fractures are coated with a very thin jet black slickenside material suggesting shearing. Minor localized blue-gray clay coatings are occasionally observed on slickenside surfaces.

2337-2345 ft.

Red to red-gray scoriaceous autobreccia (basal flow breccia ?).

2345-2378 ft.

Dark gray variably sheared micro-porphyritic andesite/basalt. Abundant fractures include a horizontal set appearing to coincide with flow features and a more vertical set likely associated with tectonic activity. The fracture surfaces are coated with a dark gray to black clay-like film. Slickenside features are commonly observed along the more vertical fractures. Minor secondary calcite and dark green clay occur, often with a botryoidal morphology, on fracture surfaces.

2378-2473 ft.

Intercalated basaltic tephra, scoriaceous lava, and dense lava. Each specific layer is usually less than 10 ft. thick. The ash-rich zones are devitrified. Red hematite alteration is locally quite intense (i.e. 2378-2382 ft.). Botryoidal clusters of secondary minerals are present on some vesicle walls. The clusters show multiple shell-like growth with calcite forming some of the layers. No significant alteration of the vesicle walls is observed.

2473-2591 ft.

Dark gray, variably vesicular andesite/basalt. The flow tends to be extremely rubbly with most fragments less than 6 inches long. Fracture surfaces generally show little to no alteration. Occasional very fine soft white minerals in fractures do not effervesce in HCl. The groundmass is very glassy. Occasional plagioclase phenocrysts appear to be quite fresh. A thin transculent coating on occasional fracture and vesicle surfaces between 2535-2560 ft. does not effervesce. Soft white botryoidal mineral clusters on fracture surfaces at 2478-2591 may be a zeolite. These clusters do not react with HCl.

2519-2616 ft.

Dark gray, grading to red, scoria with a devitrified ash matrix. Minor soft white botryoidal mineral clusters appear to be predominantly zeolite, though also may contain minor calcite.

2616-2630 ft.

Gray to dark gray, locally vesicular, strongly fractured andesite/basalt. Horizontal fractures appear to be following flow patterns and generally have fresh surfaces. Vertical fracture surfaces have a very dark gray soft slickenside coating. The rock adjacent to fractures contains minor secondary hematite. Very minor amounts of a soft white material is observed in a few vesicles. Below 2625 ft. occasional botryoidal shaped clusters in vesicles and on a few fracture surfaces contain minor calcite and unidentified soft white mineral.

2630-2657 ft.

Strongly vesicular, locally scoriaceous, andestie/basalt. Red hematite alteration is intense in the more scoriaceous zones. Traces of clear botryoidal mineral (silica ?) are present in a very few fractures. Minor traces of a soft white unidentified mineral occur on some of the fractures.

2657-2680 ft.

Gray to light gray, vesicular, partially devitrified dacitic tuff or strongly weathered dacite. The rock shows autobreccia features (2675 ft.) grading to a welded dark gray dacite tuff with occasional sub-mm orthopyroxenes crystals. Botryoidal spherulite-like features and traces of botryoidal silica are present. Silver-gray sub-mm opaque minerals (magnetite ?) are present, locally altered to a red hematite. Vesicles are generally sub-mm.

2680-2780 ft. Grading to a vesicular dacite flow.

2686-2732 ft. The dacite is very glassy and fresh. Between 2732-2756 ft. the dacite has been subject to near vertical shearing. Local brecciation occurs at 2734-2736 ft. Minor alteration of opaque (magnetite ?) minerals to hematite is particularly pronounced between 2730-2756 ft. Alteration of feldspar to white clay and/or zeolite is present in the sheared areas. Devitirfication of glass to clay increases below 2732 ft.

2780 ft. Base of the very glassy, very vesicular dacite.

2780-2820 ft.

Dark gray, very glassy, very dense, dacite with sparse mm to sub-mm feldspar phenocrysts. Fractures are filled with soft white minerals which locally react slightly to HCl. Devitrification of the glassy groundmass occurs in the more fractured zones. The basal 4 ft. of the unit is a welded autobreccia.

2820-2891 ft.

Intercalated scoria and dark gray, variably vesicular, andesite. The vesicles in the denser flow rock are typically lined with clay, which in turn is overlain by mm to sub-mm white botryoidal clusters and a white unidentified zeolite. Locally (i.e. 2846 ft.) the vesicles contain a late stage dark green clay. Minor red hematite alteration is common throughout the rock, becoming intense in scoriaceous zones.

2891-2958 ft.

Dark gray, variably vesicular andesite. The rock is very glassy with sparse plagioclase phenocrysts. Vesicles and fractures contain white mm to sub-mm precipitation clusters. No calcite is observed in these clusters. Vesicles and fractures are commonly lined with a gray to blue-gray clay. Many near vertical tectonic fractures are coated with a very dark green-gray clay. Minor red hematite alteration is common throughout.

2958-2965 ft.

Red to red-gray scoria. Red hematite is pervasive. White mm to sub-mm sized botryoidal clusters are common in many of the vesicles. When the clusters are broken they tend to show layered morphology. They do not react to HCl.

2965-3002 ft.

Dark gray hypocrystalline microporphyritic andesite/basalt. Secondary alteration of groundmass includes both red hematite and dark green clay, both appear to occupy most of the mafic mineral sites. The top 7 ft. of the flow is extremely vesicular to scoriaceous. Vesicles and occasional fractures contain secondary calcite and a minor coating of blue to blue-gray clay. Vertical fractures appear to be tectonic related and are coated with very dark gray to black slickenside striations suggesting horizontal to oblique movement. These fractures also contain secondary calcite and red hematite staining.

3002-3016 ft.

Red to very dark gray scoria and agglutinate. Secondary red hematite is pervasive. White mm to sub-mm botryoidal mineral clusters occur along the walls of some of the vesicles. These clusters appear to contain white cores, locally containing calcite, and are coated with a hard clear mineral (silica ?).

3016-3108 ft.

Dark gray, glass-rich, variably vesicular dacite with sparse sub-mm feldspar phenocrysts. The rock is generally very fresh. Brecciated zones, usually with developed slickenside surfaces, occur at 3020-3026 ft; 3041-3050 ft; and at 3099 ft. The very vesicular zones often show autobreccia features. A few of the vesicles and fractures contain secondary calcite and silica.

3108-3139 ft.

Dark gray to dark red-gray scoria and scoriaceous basaltic andesite. The rock is generally fresh. Secondary red hematite and minor secondary red-gray clay alteration is most pronounced in the scoriaceous zones. The vesicles contain transculent to white botryoidal clusters that react to HCl very slightly when broken. Locally minor blue-gray clay coats a few of the fractures and vesicles.

3139-3190 ft.

Dark gray, dense, hypocrystalline basaltic andesite with very rare mm-sized plagioclase phenocrysts. The rock has been sheared, resulting in oblique to vertical fractures coated with soft, black to gray-green slickensides. Occasionally vesicles and fracture surfaces contain minor secondary calcite. Very rare red hematite alteration occurs in microcrystalline mafic mineral sites.

3190-3228 ft.

Red to red-gray, locally dark gray, scoriaceous autobreccia, apparently the basal portion of the above basaltic andesite flow. Secondary minerals are a/a with obvious marked increase in secondary hematite.

3228-3243 ft.

Dark gray vesicular basaltic andesite. The rock appears to be generally fresh with pervasive hematite alteration of both the groundmass and mafic minerals. Traces of calcite are present. Vesicles are lined with a dark green-gray clay and are often partially filled with a non-effervescing clear to white zeolite and possible minor silica.

3243-3250 ft.

Red-gray to gray, lithified, devitrified tephra showing a well developed eutaxitic texture. Denser lithic clasts are dominantly sub-angular to sub-rounded basaltic fragments. Note: Light gray eutaxitic devitrified clasts between 3245-3249 ft. may be collasped pumice fragments.

3250-3269 ft.

Dark gray scoria and scoriaceous welded flow breccia. White fracture and vesicle filling mineral clusters, locally botryoidal, contain minor to trace calcite, microcrystalline zeolite, and possibly a thin coating of cryptocrystalline silica. Red hematite alteration of mafic minerals and groundmass is common. Minor dark green clay alteration along fractures and vesicle walls is observed.

3269-3321 ft.

Dark gray, flow banded basaltic andesite. Minor sub-mm to mm plagioclase phenocrysts are present along with minor mm-sized hematite and clay altered phenocryst which may have been olivine. Traces of secondary calcite are present in the groundmass. Red hematite alteration of mafic minerals and groundmass is intermixed with dark gray-green clay alteration. The clay appears to have formed subsequent to the hematite. Occasional vesicles are filled with secondary calcite, a light green-gray transculent clay-like mineral, and possible minor silica. Soft slickenside clay-like coatings occur along more vertical oriented fractures and are locally overlain with calcite. With increased depth the amount of hematite alteration decreases significantly and the dark green-gray clay becomes the dominant groundmass alteration product. Secondary calcite continues as above.

3321-3332 ft.

Orange to orange-gray lithified basaltic tephra showing coarse ill-defined bedding planes.

-grading to-

3332-3338 ft.

Gray to dark green-gray devitrified lithic tuff. The tuff is well compacted and locally shows eutaxitic texture. The ash component and many of the lithic fragments have been strongly altered to a dark green-gray clay. Soft white very fine crystalline secondary minerals include minor calcite and probably zeolite. The occurrence of red hematite is a relic aspect of occasional lithic fragments.

3338-3349 ft.

Dark gray, irregularly vesicular basaltic andesite. The groundmass shows extensive dark green-gray clay alteration on a microscopic level. Traces of secondary calcite and a dark green-gray clay have formed on vesicle walls. Vesicles near fracture surfaces contain white secondary layered cryptocrystalline silica with minor calcite. Occasional vesicles have a initial lining of dark green-gray clay, followed by calcite and cryptocrystalline silica, followed by white soft clay, followed by mm to sub-mm length druse quartz crystals. Sample taken from 3340 ft.

3349-3352 ft.

Red-gray devitrified ash.

3352-3408 ft.

Dark gray, variably vesicular, dense basaltic andesite with both red hematite and green-gray clay alteration disseminated in the groundmass. Secondary calcite occurs as a minor mineral disseminated through throughout the groundmass, and in vesicles and veins. Calcite is associated with secondary quartz in larger vesicles and veins. Light to very dark green-gray clay, locally displaying a microbotryoidal morphology, lines vesicle walls. Thin bladed calcite clusters overlying dark clay are present in a few of the larger vesicles. A soft, dark gray to black clay-like slickenside coating is present on the more veritcal fractures, commonly associated with minor secondary calcite.

3408-3445 ft.

Red-gray to very dark gray scoriaceous to vesicular basaltic flow breccia. The more scoriaceous portions are often hematite-altered. The more dense portions and black scoriaceous portions show red hematite alteration disseminated in the groundmass, followed by dark green-gray clay forming at the expense of hematite. White fracture and vesicle fillings include minor calcite, clear cryptocrystalline silica and an unidentified soft white mineral (zeolite?).

3445-3535 ft.

Dark gray to gray dense dacite with minor sub-mm plagioclase phenocrysts. The rock is generally very fresh with local minor disseminate calcite and minor secondary dark green-gray clay alteration near some fo the fracture surfaces. The vesicles and some of the fracture are coated with a light blue-gray clay, overlying a dark gray to black slickensice patina on many of the vertical fractures. Cryptocrystalline silica is occasionally observed in fractures and vesicles. Secondary calcite crystals are common in both fractures and vesicles. A few of the fractures contain thin layers of fine crystalline pyrite, commonly overlain by a thin film of light blue-gray clay. Pyrite appears to be most most commonly associated with slickenside surfaces. The bottom 6 ft. is extremely fractured.

3535-3542 ft.

Red to red-gray flow breccia.

3542-3552 ft.

Orange to green-gray devitrified lithic tuff with a eutaxitic texture. The upper portion has a red to orange color suggesting thermal alteration.

3552-3573 ft.

Dark gray, vesicular basaltic andesite with local flow-breccia fratures. Red hematite and dark green clay alteration are common in the groundmass. Vesicles commonly contain layered botryoidal silica and calcite.

3573-3610 ft.

Gray, fresh, hypocrystalline, feldspar porphyritic dacite with local variable white zeolite (and clay ?) alteration of feldspar

phenocrysts. Fractures and occasional vesicles contain cryptocrystalline silica and a very fine soft white mineral (zeolite ?). One foot of black very glassy brecciated dacite is present at the bottom of of this unit.

3610-3628 ft.

Dark gray, slightly vesicular, basaltic andesite with minor red hematite and pervasive dark green-gray clay alteration of the groundmass. Clear to milky cryptocrystalline silica is common in both vesicles and fractures. Secondary calcite formed as an early stage precipitation mineral along fractures is associated with minor fine crystalline pyrite. Late stage clear thick-bladed zeolites (?) also occurs in vesicles.

3628-3639 ft.

Red-gray to dark gray vesicular basaltic andesite flow breccia with white thick-bladed zeolites(?) filling a few of the vesicles and many of the fractures.

3639-3651 ft.

Dark gray, slightly vesicular, aphanitic basaltic andesite with minor reliced red hematite alteration and pervasive green-gray clay alteration of the groundmass. Minor secondary calcite appears disseminate through the groundmass and along thin fractures. Thicker fractures contain secondary calcite and cryptocrystalline silica. Below 3647 ft. a coarse autobreccia texture becomes dominant.

3651-3659 ft.

Flow breccia, grading into an extremely vesicular, hematite altered, basaltic andesite. Secondary clacite, a unidentified zeolite, and possible cryptocrystalline silica has formed in the vesicles.

-grading to-

3659-3681 ft.

A dense slightly vesicular basaltic andesite. Dark green-gray clay and minor red hematite alteration are common throughout the groundmass. Secondary calcite and cryptocrystalline silica fill vesicles and occasional fractures. Possible minor zeolites may occur in vesicles and fractures.

3681-3715 ft. (End of section logged by Columbia Geoscience)

Gray, moderately fresh, feldspar microporphyritic dacite with mafic minerals altered to a dark green-gray clay. Mafic minerals appear to have included orthopyroxene. Both the glassy groundmass and the feldspar crystals appear to be fresh, except where the rock has been sheared. Fracture fillings appear to be dominanted by a clear to white, very fine crystalline layers, possibly quartz with traces of calcite. A portion of the very fine crystalline vein-filling mineral is soft and suggestive of zeolite.