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LOCATION AND AGE OF FORAMINIFER SAMPLES COLLECTED BY CHEVRON PETROLEUM GEOLOGISTS IN CALIFORNIA

by

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1 INTRODUCTION AND BACKGROUND

1.1 *Need for information*

Most of the geologic maps published for parts of central California in the past century have been made without the benefit of ages from microfossils. The ages of Cretaceous and Tertiary rocks in the mostly poorly exposed and structurally complex sedimentary rocks represented in the Coast Ranges are critical in determining stratigraphic succession or lack of it, and in determining whether the juxtaposition of similar appearing but different age formations means that a fault is present. Since the 1930's, at least, oil company geologists have used microfossils to assist them in geologic mapping and in determining the environments of deposition of the sediment containing the microfossils. This information has been so confidential that even the names of species have been coded to prevent disclosure. In the past 20 years, however, the attitude of petroleum companies about this information has changed, and many of the formerly confidential materials and reports are now available. We report here on 33,540 Chevron foraminifer samples from surface localities in nearly 600 U. S. Geological Survey 7.5' quadrangles in California. To our knowledge, this collection is the largest ever released by a petroleum company for the West Coast. The information from the slides can be used to update geologic maps prepared without the benefit of microfossils, to analyze the depth and temperature of ocean water covering parts of California during the Mesozoic and Cenozoic Eras, and for solving nomenclature and other scientific problems.

1.2 *Partial transfer of Chevron materials beginning in 1989*

A USGS project was begun in 1989 to make digital geologic maps of all counties in the entire San Francisco Bay region and to convert these county maps to at least the following 1:100,000-scale quadrangles: Palo Alto, San Francisco, Napa, and Stockton. Work on digitizing the San Jose quadrangle was begun nearly a decade earlier and published by Wentworth and others (1999). Arco, Shell, Exxon, Unocal, and Chevron all contributed an estimated total of 25,000 microscope slides and residues containing foraminifers along with the paleontology (hereinafter abbreviated as paleo) reports that identified the content and age of these samples to help update the geologic maps published previously. These data have been incorporated into new digital geologic maps of Contra Costa County (Graymer and others, 1994), Alameda County (Graymer and others, 1996), Santa Cruz County (Brabb, 1997), San Mateo County (Brabb and others, 1998), and San Francisco, Marin, Sonoma, Napa, and parts of other counties in the northern San Francisco Bay region (Blake and others, 2000, 2002, and Graymer and others, 2002). Chevron also provided sonic logs and paleo information for many oil test wells in the San Francisco Bay region that show the depth of different geologic units and their density. These data and the geologic maps have been used by Wentworth and others (1997) and Jachens and others (1997) to determine the seismic velocities of the

geologic formations and to prepare a 3-D seismic-velocity model that can explain the propagation of seismic waves from local earthquakes.

1.3 *Transfer of Chevron material in 1997*

Chevron closed their paleo laboratory in Houston in 1997. Their collection of an estimated 80,000 slides containing foraminifers (mostly three samples per slide) covering the West Coast from Baja, Mexico, to the North Slope of Alaska was in jeopardy of being discarded. Chevron management was persuaded to ship this collection to Menlo Park so that it could be transferred to permanent repositories on the West Coast, along with the original locality maps and paleo reports. Alaskan slides and paleo materials have been sent to the State of Alaska Repository in Eagle River. Washington and Oregon slides and other materials are in the process of being shipped to the Burke Museum in Seattle. The original locality maps for all of the western states have been deposited in the USGS library in Menlo Park, California. The California microscope slides and other materials have been given to the California Academy of Sciences in San Francisco.

1.4 *Scope of this report*

This report provides information about location and age of 33,539 foraminifer samples collected by Chevron geologists from onshore surface localities in California. The information is in five Excel data files labeled "Chevron Data File #1 through Chevron Data File #5" along with a readme file and an explanation sheet for the columns in each file. Chevron localities are plotted on the equivalent of nearly 600 7.5' quadrangle maps in the following 40 counties: Alameda, Almador, Colusa, Contra Costa, Del Norte, Fresno, Glenn, Humboldt, Imperial, Kern, Kings, Lake, Los Angeles, Marin, Mariposa, Mendocino, Merced, Monterey, Napa, Orange, Riverside, San Benito, San Bernardino, San Diego, San Joaquin, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Siskiyou, Solano, Sonoma, Stanislaus, Sutter, Tehama, Trinity, Ventura, and Yolo. Microfossil slides were prepared for collections from 450 of the locality maps, providing the opportunity for research scientists to check the composition, variety, and age of the collections. The other 149 maps have localities, but no foraminifer slides were prepared, indicating that the collections were probably barren of foraminifers. However, other information may be available for these localities, such as paleo reports, porosity or permeability tests, or radiometric data. A separate report documenting Chevron paleo data for 1,554 oil test wells in Northern California has been prepared by Brabb and others (2001).

2 PREPARATION OF THE DATA SET

2.1 *Excel spreadsheets*

Five Excel spreadsheets are provided for the data pertaining to each locality represented by foraminifers on a slide. Chevron Data File #1 has information on the location and age of 32,731 localities arranged in numerical order. Chevron data file #2 has the same information sorted by quadrangle in alphabetical order. This file would probably be the most useful one for geologists making geologic maps. Chevron data file #3 shows all Chevron numbers on all quadrangle maps, slide or no slide, so that duplicate numbers can be easily identified. Chevron data file #4 is greatly abbreviated from Chevron data file #3 to show which quadrangles have slides with foraminifers and which ones do not. Chevron data file # 5 describes an additional 808 localities with foraminifer slides identified by quadrangle name and number or letter.

2.2 *Card files*

Two 3- x 5-inch card file boxes were among the materials received from Chevron. Each card is for a different locality and each card has on the back a list of the foraminifers identified by a Chevron paleontologist. Some of this information is duplicated in paleo reports, but many of the cards are for slides with no paleo reports. Some cards have a little locality information that was useful in determining where the sample was collected so that it could be identified properly on Chevron data file #1. Some cards have age information that was added directly to Chevron data file #1. Unfortunately, the card files are only for a limited number of localities in Southern California. One card file, for example, begins with Roman numeral I (1) and ends with DCCI (701). A second and similar card file begins with 1,992 and ends with 42,644, but there are major gaps and missing cards, especially from 10,132 to 42,644.

2.3 *Chevron digital file*

Some paleo information was specifically provided by Chevron to the USGS in 1994 from a proprietary computer file. The fields printed for each locality provide virtually all the information needed for Chevron data file #1 but, unfortunately, hardly any of this information was digitized for the Chevron computer file. Perhaps a dozen or two plots provided a little useful information.

3 AGE OF FAUNAS

3.1 *Main source of data*

A stack of file folders approximately 17 feet high provided most of the information on the age and location of the foraminifer faunas in the slides. The files were organized geographically, with some areas covering several counties. The files contain notes and letters written by the paleontologists, stratigraphic columns, cross-sections, foraminifer check-lists, sketch maps, and other materials. Unfortunately, perhaps a third of the

localities have no paleo information of any kind. Some ages, however, are provided on locality maps. The probable age of a fauna could also be determined by overlaying the Chevron locality map on a geologic map such as the 1:250,000-scale geologic maps made by the California Geological Survey.

The ages of the foraminifers follows the zonation of Goudkoff (1942) for the Cretaceous, modified by internal and informal zones; Laiming (1940) for the Eocene; and Kleinpell (1938) for the Oligocene and Miocene.

All ages are from foraminifers unless stated otherwise. The term "barren" refers only to foraminifers because most barren samples commonly contain diatoms, radiolarians, and other microfossils. The general character of the fauna on the slide was checked with the paleo report, when available, to help make certain that the slide was correctly located and dated. A notation of abundant planktic foraminifers on the paleo report was especially helpful because most of these are easily identified on a slide.

Some of the foraminifers used to determine the age of a sample may be in a paleo report but not on the slide. These age determinations may come from casts that did not survive washing. Rubber molds were made of some casts, and these are included on the slides.

3.2 *Supplemental sources*

A list of species but not an age was provided for several samples in paleo reports, on file cards, on check-lists, and on stratigraphic columns. The range charts of Kleinpell (1938) and Mallory (1959) were consulted to determine the probable age of the sample. If only the formation name was provided, the correlation chart of Weaver and others (1944) was used to determine the age.

4 PROBLEMS WITH DATA SETS

4.1 *Separation of the slides*

The first formidable task was to separate the estimated 80,000 foraminifer slides into piles organized by state, surface or subsurface sample, slide number for surface sample, and by county for well sample. The only consistent number on each slide indicated the drawer and cabinet numbers where the slide was stored in Houston; those cabinets had been discarded. Many slides have no geographic information, and others have no numbers to indicate whether or not the slides are from surface localities or wells. A digital print was provided by Chevron to accompany the slides, but the information for many of the wells was different from the information on the slides because most well operators have changed over time.

4.2 *Putting the slides in numerical order*

Once the apparent surface samples for California were segregated, the next task was to put them in numerical order. This task was made difficult by the fact that perhaps half the slides and paleo reports have Roman numerals to identify the localities. The Roman numerals on every slide and paleo report were converted to Arabic numerals. Another difficulty is that most of the slides have two numbers, a lot number that was assigned for an area, and a sub-lot number or letter that was assigned for a specific sample within the area. Some lots have hundreds of specific samples. Other slides have numbers that correspond to number of feet along a seismic line. Still another, and almost devastating problem, is that at least two Chevron laboratories used the same numbering system, so that a locality number on a slide could be on Chevron maps from two or more areas within California. Chevron data file #3 was designed to cope with this problem by listing the alternatives for localities with the same number.

Another problem with arranging the surface locality slides in numerical order is that samples collected seemingly in the 1930's were assigned letters and numbers within a quadrangle, such as F-4 in the Whitaker Peak quadrangle. Nearly all of those quadrangles are obsolete; some are 1:125,000-scale, some are 1:62,500-scale, and some are 1:31,250-scale. Locality A-4 in the old Dry Canyon quadrangle, for instance, is in the Canoga Park 7.5' modern quadrangle. Locality H-9 from the old Van Nuys quadrangle is in the Beverly Hills 7.5' modern quadrangle (and not the modern Van Nuys quadrangle). Because of this confusion, because letters are repeated in every quadrangle, and because the letters can also be confused with the lot system described above, these 807 surface localities that have obsolete quadrangle numbers and letters are described separately in Chevron data file #5.

4.3 *Examples of slides with limited geographic information*

Lot 684 with 45 localities illustrates some of the problems in locating slides with little geographic information on the slide or in the paleo report or index cards. The slides have "Deep Canyon" as a geographic location, but the USGS Geographic Names Information System (GNIS) for California lists 14 "Deep Canyons" in 12 counties. The mounting frame for the slides has a light tan color characteristic of Miocene and Pliocene slides for Southern California in contrast to slightly darker mounting frames for slides from other areas. Of the four candidates in the GNIS for a "Deep Canyon" in Southern California, only the Dana Point 7.5' quadrangle has Chevron localities. However, the shortened inventory of locality numbers (Chevron data file#3) indicates that locality 684 is also located in the Guinda and Simi Valley East quadrangles, but neither of these has a "Deep Canyon." Moreover, Lot 684 in the Guinda quadrangle is a single sample, and Lot 684 in the Simi Valley East quadrangle has 8 localities, indicating that the slides are probably not from those areas either. The Dana Point quadrangle

does not have Lot 684 but it does have Lot 634 with 45 localities in Deep Canyon. Apparently the Roman Numeral "L" was omitted by mistake from the locality number DCLXXXIV when the lot was plotted on the locality map.

4.4 *Examples of slides with obsolete, incorrect, or misleading quadrangle names*

Many slides have geographic names or even quadrangle names that are highly misleading. For example, slides for localities 3646 to 3653 have "Arroyo Grande quad" on each slide. The Arroyo Grande 15' quadrangle consists of the Pismo Beach, Arroyo Grande NE, and Oceano 7.5' quadrangles. None of the slides are in these quadrangles, but instead are in the Caldwell Mesa, Huasna Peak, and Chimney Canyon 7.5' quadrangles within the Nipomo and Branch Mountain 15' quadrangles. Similarly, the slide for locality 2031 is marked "Adelaida quad" but this locality is several miles from the Adelaida quadrangle, in the Santa Margarita quadrangle.

4.5 *Localities missing from maps*

An unknown number of localities were never plotted on the Chevron locality maps. If the information in the paleo report or stratigraphic column suggests that the slide is probably in the same quadrangle as a locality with a number nearly in sequence, the quadrangle name on the spread sheet is followed with a question mark and a notation is made that the locality could not be found.

4.6 *Drawer numbers on the back of slides*

Almost every slide has a letter and a number on the back referring to the cabinet and drawer where the slide was filed in Houston. The principal value of this number was in trying to locate slides that have no locality information. Similar cabinet and drawer numbers may mean that a slide was collected somewhere near a locality that has been found.

4.7 *Fortuitous help*

One other example will suffice to illustrate the difficulties in locating many slides. Locality 11338 is shown on the Las Yeguas Ranch, Santa Rosa Hills, and Simmler quadrangles. A paleo report for this locality indicates that the sample is from the Anita Shale, so the search could be narrowed if the distribution of the Anita Shale could be determined. Fortuitously, a very faint pencil notation on the side of the paleo sheet indicates that the sample is from Amoles Creek, which is only in the Santa Rosa Hills quadrangle.

4.8 *Discarded and missing slides*

Slides that have no paleo information and could not be found on a locality map were either discarded or given to the Earth Sciences Department at California State University at Long Beach to be used for teaching purposes. Most of these were barren or contained poor faunas.

Sample records and paleo reports indicate that slides were prepared for many samples that were not in the Houston collection. Presumably these slides are in regional field offices or have been lost. In general, however, most of the sample numbers on maps that do not have slides were barren, as determined from information in the paleo reports.

4.9 *Obsolete quadrangle maps*

Most of the Chevron localities were plotted on nearly 400 obsolete 1:62,500-scale or 1:125,000-scale topographic maps published by the USGS. Many were re-plotted by Chevron paleontologists on nearly 300 modern USGS 7.5′ quadrangles as the quadrangles became available, but many localities were never transferred from the older maps. Therefore, anyone looking for a locality may need to check all of the older maps as well as the 7.5′ quadrangles. The names provided on the spreadsheets are the latest versions of the USGS maps, with older and obsolete names given to help find the correct Chevron maps needed. A total of 599 of the 7.5′ quadrangle maps or their equivalents have Chevron locality numbers in California, and, of these, 450 have foraminifer slides. A complete list of the quadrangle maps with localities is provided in Chevron Data File #4. The original set of the locality maps has been deposited in the USGS Library, Menlo Park, and copies of these maps have been provided to the California Geological Survey in Sacramento.

5 OTHER INFORMATION ABOUT CHEVRON LOCALITIES

Information about porosity and permeability of the rocks and radiometric ages were provided by Chevron for many localities in California. In addition, many localities have paleo information but no slides. None of this information has been digitized but it has been given to the Earth Sciences Department, California State University at Long Beach.

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