



These gravity maps are part of a folio of maps of the Reno 1° by 2° drainage, Nevada and California, prepared under the Conterminous United States Mineral Assessment Program. Each product in the Miscellaneous Field Studies Map MF-2154 folio is designated by a different map sheet number, starting with A. The quadrangle encompassed an east-west 19,000 km² in west-central Nevada and a narrow strip on the eastern border of California.

The gravity data consist of 2,194 data points after removal of meaus or redundant data from an initial data set. Sixty-nine data points were obtained from a survey between Reno and Washoe County, Nevada (Sandberg 1958; H.W. Oliver, written commun., 1986). Fifteen data points were obtained from a gravity survey associated with seismic studies in the Fallon and Toiyabe National Forests, Nevada (H.W. Oliver, written commun., 1986). A total of 107 data points were obtained from a gravity survey by Gmelin et al. (1979) in the Toiyabe National Forest, Nevada (Springs Valley). Forty-three data points were obtained from R.N.

of labor and others, 1968, 110, *Univ. written comm.*, 1986) for an elevation of 177 points from a regional survey by Northwest University. The present study used the elevation data checked for accuracy. The approach during the present compilation was to retain only one data point from the survey judged to be of higher quality or from the survey with the most complete elevation data.

Elevations also were updated during the present compilation. Computer programs were developed to compare the elevation data and compares station elevations with linearly interpolated digital topographic data. Data points generally were discarded if plotted elevations were judged to be greater than about 10 m from interpolated elevations. The program provided for the identification of nearby benchmarks, spot elevations, or road junctions. Except for the data from the present study, the elevation data were from the 1971 (written comm., 1988), elevation sources and associated accuracies for the 1971 data were estimated as follows:

- 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614

Values of observed gravity were tied to the International Gravity Standardization Network of 1971 (IGSN71) (Morelli, 1974). The primary gravity base station is located at the University of Illinois, Urbana-Champaign for the present study is located near the southeast corner entrance of J.G. Scragham Engineering Mines Building at the University of Illinois, Urbana, as described in Figure 1. This site was made as a secondary gravity base station for PALLON, AIGC2 and AIGC3 (Fig. 1). Observed-gravity data from PALLON surveys were adjusted to the IGSN71 datum by direct ties during the present survey and by statistical analysis of assumed repeated observations at the same locations by different gravity surveys.

PREVIOUS GEOPHYSICAL STUDIES

Listings of gravity data without interpretations were cited in the section on 'Compilation and reduction of gravity data'. Thompson and Swick (1958) reported the structural significance of gravity data collected in the San Antonio City, Texas, area. Thompson and Swick (1960) used an east-west seismic line through Falls Church, Virginia. Washburn et al. (1965) interpreted gravity data collected in a large area near the mouth of the Colorado River, California. The U.S. Geological Survey configuration of basement beneath Warm Springs Valley for a study applied to groundwater studies. Erwin (1970) interpreted a gravity map of an area near Grantsville, Utah. Swick (1970) interpreted gravity data and gravity data collected in the Silverado-Santa Luis geothermal area, California. Erwin (1970) used gravity data to interpret the possible deep drill hole near Napa, Nevada. Coghil (1979) studied the possible

relation of seismic activity with crustal structure indicated by seismic and gravity data in a large region of the western Great Basin, including the Reno quadrangle. Tabor and others (1983) interpreted gravity and shallow seismic data collected near Washoe City, Nevada. Benoit and Butler (1983) reported on geothermal studies at four localities in the Reno quadrangle. Schaefer (1983) interpreted gravity data for a hydrologic study of Dixie Valley.

Interpretation of gravity data contributes to the understanding the regional geology for the purpose of evaluating mineral resource potential (for example, Brooks and others, 1987; Hardyman and others, 1987; McKee and others, 1987; Diggles and others, 1988; Vercoutere and others, 1988). Gravity anomalies reflect the effect of sedimentary deposits or lateral density contrasts between adjacent rocks, with higher values of gravity anomalies located over denser rocks.

GRAVITY ANOMALIES ASSOCIATED WITH LAKES

The greatest contrast of density in the Reno quadrangle is between lake water and the surrounding bedrock at the same range of depths. The gravity low associated with Lake Tahoe is not apparent, however, because there are no points along the slope of the lake shore. The points along the lake shore north of Glenbrook to generate a gravity gradient over the edge of the expected gravity low associated with Lake Tahoe. The gridding and contouring programs interpolated values toward data points to the west across the lake and to the east toward geologic terranes with density contrasts and values of associated gravity anomalies unrelated to the gravity field near the edge of Lake Tahoe.

The gravity anomaly associated with Pyramid Lake is the most intense closed gravity low in the quadrangle. As in the case of Lake Tahoe, the lack of detail in the gravity data in this area may have diminished the observed effect of water in Pyramid Lake. Most of the amplitude of the gravity low reflects the thickness of underlying sediments that fill the basin beneath the lake, as evidenced by the southeastward continuation of the intense gravity minimum along the Truckee River. Gravity lows also are located over Washoe and Carson Lakes, but the gravity low over Pyramid Lake reflects the thickness of underlying basins rather than the effect of water in the lakes. The intensity of the gravity low over Pyramid Lake is approximately 1.5 times that of the gravity low over Carson Lake.

The configurations of gravity lows in valleys and basins mostly reflect the thickness of sediments beneath the valleys and basins, because sediments have low densities in contrast to the surrounding bedrock at the same range of elevations (depths) as the sediments. As a broad example, the average density of sediments is about 1.9 to 2.3 g/cm³ in contrast to average bedrock densities of about 2.5 to 2.7 g/cm³ or greater. On the basis of gravity modeling, Jachens and Moring (1990) applied the function of sediment density with depth to estimate the thickness of sedimentary deposits beneath the Colorado Plateau. In their study, applying a second function of density contrast with depth, they also

estimated the thickness of Cenozoic volcanic rocks where Cenozoic volcanic rocks are exposed. Gravity lows are clearly associated with most sedimentary basins in the Reno quadrangle. Furthermore, in the case of a large valley such as Carson Sink, deep basins within valleys are delineated by separate gravity zones. Although mostly on the basis of two gravity stations at the east end of a valley, the Reno Sink, the Lone Rock Valley, and the Peterman Valley, the pattern of outcrop of Cenozoic volcanic rocks indicate that a shallow basement possibly consisting of volcanic source rocks near Lone Rock separates two large basins. The depression beneath the Peterman Mountains is a complex, but nearly flat-topped gravity high with a low amplitude between the Fallion Indian Reservation and the Stillwater National Wildlife Refuge suggests intrabasin density contrasts within bedrock concealed at shallow

GRAVITY ANOMALIES ASSOCIATED WITH TERTIARY IGNEOUS ROCKS

Sher (1969, p. 19) postulated that a caldera may be located beneath Carson Sink. Although the interpretations of detailed geologic features are not consistent, the following geologic maps of the main part of the Carson Sink region have been published: 1964, 1968, 1972, 1974, 1976, 1977, 1978, 1981, 1984, 1986, 1987, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650,

A north-elongated 16- by 35-km gravity low with an amplitude of less than 10 mGal, which overlies an extensive exposure of Tertiary volcanic rocks in most of the central and northern parts of the study area (Fig. 1). In addition to thick volcanic rocks, because the anomaly extends southward into pre-Cenozoic rocks and northward into Warm Springs Valley. Extensive gravity lows in the Truckee Range and along the northwest edge of the Hot Springs Mountains probably reflect the subsurface vertical extent of exposed volcanic rocks and the effect of underlying basement rocks with low densities. The gravity anomalies in the central and northern parts of the study area, where most extensive rocks, probably do not have distinct associated gravity anomalies, because their volumes are small or they are partly surrounded by pre-Cenozoic rocks with similar densities.

GRAVITY ANOMALIES ASSOCIATED WITH PRE-CENOZOIC ROCKS

Gravity highs are associated with most mountain ranges in the quadrangle, because rocks beneath the ranges are denser than sediments at the same elevation in adjacent valleys. Gravity highs also are associated with pre-Cenozoic outcrops adjacent to Cenozoic volcanic rocks, because pre-Cenozoic rocks are generally denser than Cenozoic volcanic rocks. Edges of gravity highs associated with isolated outcrops of pre-Cenozoic rocks in the Reno quadrangle, except where there are extensive outcrops of pre-Cenozoic rocks and interfingering regional gravity gradients near Carson City, apparently reflect the same density contrast. Furthermore, amplitudes of surrounding gravity gradients qualitatively reflect

the steepness of contacts along edges of concealed pre-Cenozoic rocks, an important consideration when estimating the extent of pediments along the edges of valleys. Pre-Cenozoic rocks may be concealed at shallow depth beneath gravity highs that do not enclose pre-Cenozoic rocks, for example, beneath elongate gravity highs to the southwest of the Pyramid Lake-Truckee River gravity low, to the southwest of the southwest end of the West Humboldt Range, the Dead Camel Mountains, and the Lahontan Mountains. Alternatively, the gravity highs in the Dead Camel and Lahontan Mountains may reflect thick accumulations of Cenozoic basalt (D.A. John, written comm., 1991).

The steepest gravity gradient in the quadrangle overlies the south side of Marble Bluff (southeast of Pyramid Lake). The gradient is too high to be associated only with the interface between the dense rocks composing Marble Butte and the sediments beneath Pyramid Lake and Truckee Valley. The rocks beneath Marble Bluff and beneath the northeastward continuation of the gravity high must be significantly denser than basement rocks beneath valley sediments and beneath areas outside other edges of the gravity high.

A distinct gravity high is centered over pre-Cenozoic intrusive rocks near the northwest flank of the Barnett Hills (northeast of Rawhide Flats in the south-central part of the quadrangle). Gravity highs also overlie pre-Cenozoic intrusive rocks in contact with other pre-Cenozoic rocks near Churchill Butte and over an unnamed hill between North Valley and the

northwest edge of Hot Springs Flat. The gravity high near Churchill Butte extends northeastward beneath Churchill Valley. Sources of these gravity highs are uncertain without further studies of compositions and densities of nearby pre-Cenozoic rocks.

Trends of the basins and ranges reflect the underlying tectonic fabrics and may show a pattern that reflects the existing stress field. Axes of gravity anomalies are generally perpendicular to the principal stress directions. Gravity anomalies are irregular in detail, generally follow topographic trends of valleys. The effect of topography is taken into account in calculating gravity anomalies so that the high-frequency topographic features are not reflected in the gravity anomalies. Rocks beneath featureless topography such as Carson Sink and Plover are homogeneous. Figure 2 shows that trends of gravity highs and lows are generally perpendicular to the principal stress directions. Gravity anomalies follow north near the Coast Range in southeastern California. A plot of lines that follow axes of crests and troughs of gravity anomalies (Fig. 2) may reflect the high-frequency components of the stress field. The gravity map of Figure 2 was derived from the manually derived from the isostatic residual gravity map (sheet 2), because computer-generated extrema from a 5-km data grid are clustered near the lines but are too sensitive to local variations of the topographic stress field. The gravity map of Figure 2 is derived from the topographic map smoothly continuous than computer-generated lines over the steepest gravity gradients, which are useful to approximately delineate steep contacts between normal-fault zones such as those along the southwest edge of Pyramid Lake.

and both sides of the Stillwater Range. Although there is some discontinuity and superposition of local trends with more regional differences, a southeast-to-south-southeast-trending zone through the Warm Springs Valley, Pyramid Lake, Lahontan Reservoir, and Desert Mountain's structural systems (fig. 2; John and others, in press, fig. 12), which apparently truncate major northeast-trending gravity-anomaly trends to the northeast. Gravity-anomaly trends are sharply changed across the Stillwater Range, and the Pinetone Mountains, and the Singatse and Desert Mountains zones are not reflected by gravity-anomaly trends (fig. 2). Gravity-anomaly trends are distorted near structurally deformed areas in the Stillwater Range and between the Pine Nut Mountains and the Singatse Range. Effects of bending, horstealing, chevroning, and secondary faults on the north-south-trending zone are present, further speculation concerning the significance of the gravity-anomaly trends in relation to boundaries of major provinces is beyond the scope of this report.

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