ARIZONA ZINC AND LEAD DEPOSITS

PART II
ARIZONA BUREAU OF MINES, GEOLOGICAL SERIES NO. 19,
BULLETIN NO. 158

SIXTY CENTS
(Free to Residents of Arizona)

PUBLISHED BY
University of Arizona
TUCSON, ARIZONA
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER I.—INTRODUCTION. BY ELDRED D. WILSON</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope of Report</td>
<td>7</td>
</tr>
<tr>
<td>Production Summary</td>
<td>7</td>
</tr>
<tr>
<td>Districts</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER II.—DRAGON MOUNTAINS. BY ELDRED D. WILSON</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situation and Access</td>
<td>10</td>
</tr>
<tr>
<td>Topography</td>
<td>10</td>
</tr>
<tr>
<td>Rocks</td>
<td>11</td>
</tr>
<tr>
<td>Structure</td>
<td>12</td>
</tr>
<tr>
<td>History of Mining</td>
<td>12</td>
</tr>
<tr>
<td>Production</td>
<td>13</td>
</tr>
<tr>
<td>Gleeson and Courtland Areas</td>
<td>13</td>
</tr>
<tr>
<td>Physical Features</td>
<td>13</td>
</tr>
<tr>
<td>Structure</td>
<td>13</td>
</tr>
<tr>
<td>Ore Deposits</td>
<td>14</td>
</tr>
<tr>
<td>Tom Scott Mine</td>
<td>14</td>
</tr>
<tr>
<td>Silver Bill Mine</td>
<td>15</td>
</tr>
<tr>
<td>Mystery Mine</td>
<td>17</td>
</tr>
<tr>
<td>Defiance Mine</td>
<td>19</td>
</tr>
<tr>
<td>Dragoon Workings</td>
<td>19</td>
</tr>
<tr>
<td>Last Chance or 1907 Mine</td>
<td>20</td>
</tr>
<tr>
<td>Central Dragoon Mountains Area</td>
<td>20</td>
</tr>
<tr>
<td>San Juan or Gordon Mine</td>
<td>20</td>
</tr>
<tr>
<td>Abril Mine</td>
<td>23</td>
</tr>
<tr>
<td>Senecia Mine</td>
<td>26</td>
</tr>
<tr>
<td>Other Mines in Central Dragoon Area</td>
<td>28</td>
</tr>
<tr>
<td>Northern Dragoon Mountains Area</td>
<td>28</td>
</tr>
<tr>
<td>Golden Rule Mine</td>
<td>28</td>
</tr>
<tr>
<td>Hubbard Mine</td>
<td>29</td>
</tr>
<tr>
<td>References, Dragoon Mountains</td>
<td>29</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER III.—SWISHELM DISTRICT. BY F. W. GALBRAITH AND W. B. LORING</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Features</td>
<td>30</td>
</tr>
<tr>
<td>Rocks</td>
<td>30</td>
</tr>
<tr>
<td>Structure</td>
<td>32</td>
</tr>
<tr>
<td>Ore Deposits</td>
<td>32</td>
</tr>
<tr>
<td>Occurrence</td>
<td>32</td>
</tr>
<tr>
<td>Production</td>
<td>32</td>
</tr>
<tr>
<td>Mountain Queen or Scribner Mine</td>
<td>33</td>
</tr>
<tr>
<td>Chance Mine</td>
<td>34</td>
</tr>
<tr>
<td>Swisshelm Mountain Gold and Silver Mining Company</td>
<td>35</td>
</tr>
<tr>
<td>References, Swisshelm District</td>
<td>36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER IV.—HUACHUCA MOUNTAINS. BY ELDRED D. WILSON</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Features</td>
<td>36</td>
</tr>
<tr>
<td>Rocks</td>
<td>36</td>
</tr>
<tr>
<td>Structure</td>
<td>37</td>
</tr>
<tr>
<td>Ore Deposits</td>
<td>37</td>
</tr>
<tr>
<td>History and Production</td>
<td>37</td>
</tr>
<tr>
<td>State of Texas Mine</td>
<td>38</td>
</tr>
<tr>
<td>Panama or Manila Mine</td>
<td>39</td>
</tr>
<tr>
<td>Other Zinc and Lead Mines</td>
<td>40</td>
</tr>
<tr>
<td>References, Huachuca Mountains</td>
<td>40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER V.—ORO BLANCO OF RUBY DISTRICT.</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>41</td>
</tr>
<tr>
<td>History</td>
<td>41</td>
</tr>
<tr>
<td>Production, Oro Blanco District</td>
<td>42</td>
</tr>
<tr>
<td>Mineralogy of the Ores</td>
<td>42</td>
</tr>
<tr>
<td>Montana Mine</td>
<td>43</td>
</tr>
<tr>
<td>Production</td>
<td>43</td>
</tr>
<tr>
<td>Geology. By George M. Fowler</td>
<td>43</td>
</tr>
<tr>
<td>Chapter</td>
<td>Title</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>VI</td>
<td>Empire District</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
</tr>
<tr>
<td></td>
<td>Physical Features</td>
</tr>
<tr>
<td></td>
<td>Rocks</td>
</tr>
<tr>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Ore Deposits</td>
</tr>
<tr>
<td></td>
<td>Types</td>
</tr>
<tr>
<td></td>
<td>Production</td>
</tr>
<tr>
<td></td>
<td>Total Wreck Mine</td>
</tr>
<tr>
<td></td>
<td>Hilton Area Mines</td>
</tr>
<tr>
<td></td>
<td>References, Empire District</td>
</tr>
<tr>
<td>VII</td>
<td>Banner District</td>
</tr>
<tr>
<td></td>
<td>Physical Features</td>
</tr>
<tr>
<td></td>
<td>History</td>
</tr>
<tr>
<td></td>
<td>Production</td>
</tr>
<tr>
<td></td>
<td>Rocks</td>
</tr>
<tr>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>Types of Ore Deposits</td>
</tr>
<tr>
<td></td>
<td>Zoning</td>
</tr>
<tr>
<td></td>
<td>Age of Mineralization</td>
</tr>
<tr>
<td></td>
<td>Blue Bird Mine</td>
</tr>
<tr>
<td></td>
<td>References, Banner District</td>
</tr>
<tr>
<td>VIII</td>
<td>Silver and Eureka Districts</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
</tr>
<tr>
<td></td>
<td>Physical Features</td>
</tr>
<tr>
<td></td>
<td>Rocks</td>
</tr>
<tr>
<td></td>
<td>Structure</td>
</tr>
<tr>
<td></td>
<td>History of Mining</td>
</tr>
<tr>
<td></td>
<td>Production</td>
</tr>
<tr>
<td></td>
<td>Veins</td>
</tr>
<tr>
<td></td>
<td>Mines</td>
</tr>
<tr>
<td></td>
<td>Red Cloud Mine</td>
</tr>
</tbody>
</table>
### TABLE OF CONTENTS — Continued

| Black Rock Mine                                      | 93 |
| Pacific and Mandan Claims                           | 94 |
| Papago Mine                                          | 96 |
| Riho Vein                                            | 96 |
| Riverview Claims                                     | 97 |
| Mendevil Claims                                      | 97 |
| References, Silver and Eureka Districts             | 97 |

**CHAPTER X.—CASTLE DOME DISTRICT. BY ELDRED D. WILSON**

| Physical Features                                   | 98 |
| Rocks                                                | 98 |
| Structure                                            | 101 |
| Veins                                                | 101 |
| History                                              | 103 |
| Flora Temple Claim                                   | 106 |
| Senora Claim                                         | 107 |
| Little Dome Claim                                    | 110 |
| Big Dome Claim                                       | 110 |
| Buckeye Vein                                         | 110 |
| Hull or Rialto Claims                                | 111 |
| Cleveland-Chicago Vein                               | 112 |
| Adams Claims                                         | 113 |
| Mabel Claims                                         | 113 |
| Lincoln or Colorado Claims                           | 114 |
| Annie Mine                                           | 114 |
| References, Castle Dome District                     | 114 |

**INDEX**

<p>| 116 |</p>
<table>
<thead>
<tr>
<th>FIGURE</th>
<th>DESCRIPTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIGURE 1</td>
<td>Index map showing distribution of Arizona zinc and lead districts</td>
<td>8</td>
</tr>
<tr>
<td>FIGURE 2</td>
<td>Cross section of Gleeson Ridge through Silver Bill and Mystery mine stopes, looking N. 30 degrees W.</td>
<td>16</td>
</tr>
<tr>
<td>FIGURE 3</td>
<td>Sketch map of Silver Bill and Mystery workings as of 1925</td>
<td>18</td>
</tr>
<tr>
<td>FIGURE 4</td>
<td>Cross section of ridge at San Juan mine, looking north</td>
<td>22</td>
</tr>
<tr>
<td>FIGURE 5</td>
<td>Generalized map of Abril mine</td>
<td>25</td>
</tr>
<tr>
<td>FIGURE 6</td>
<td>Generalized cross section through Abril mine stopes, looking east</td>
<td>27</td>
</tr>
<tr>
<td>FIGURE 7</td>
<td>Generalized columnar section, Swisshelm Mountains, Arizona</td>
<td>31</td>
</tr>
<tr>
<td>FIGURE 8</td>
<td>Cross section of Mountain Queen and Chance mine areas, looking north</td>
<td>33</td>
</tr>
<tr>
<td>FIGURE 9</td>
<td>Map showing surface geology of Montana mine and vicinity</td>
<td>44</td>
</tr>
<tr>
<td>FIGURE 10</td>
<td>Montana mine, longitudinal projection, looking north. Shaded areas indicate stopes</td>
<td>47</td>
</tr>
<tr>
<td>FIGURE 11</td>
<td>Montana mine, vertical section across veins, looking west. Line of section approximately 130 feet east of Rough and Ready dike</td>
<td>48</td>
</tr>
<tr>
<td>FIGURE 12</td>
<td>Plan of underground workings, Total Wreck mine</td>
<td>54</td>
</tr>
<tr>
<td>FIGURE 13</td>
<td>Geologic map of part of Copper Creek area</td>
<td>58</td>
</tr>
<tr>
<td>FIGURE 14</td>
<td>Cross sections along lines A-B and C-D of Figure 13</td>
<td>60</td>
</tr>
<tr>
<td>FIGURE 15</td>
<td>Plan and cross sections of Blue Bird mine workings</td>
<td>64</td>
</tr>
<tr>
<td>FIGURE 16</td>
<td>Generalized geologic map of Seventy-Nine mine area</td>
<td>68</td>
</tr>
<tr>
<td>FIGURE 17</td>
<td>Cross section through Dripping Spring Range, looking northwest</td>
<td>71</td>
</tr>
<tr>
<td>FIGURE 18</td>
<td>Cross section through Massive Pyrite ore body, Seventy-Nine mine, looking east</td>
<td>75</td>
</tr>
<tr>
<td>FIGURE 19</td>
<td>General geologic map of silver district</td>
<td>85</td>
</tr>
<tr>
<td>FIGURE 20</td>
<td>Red Cloud mine, longitudinal section of vein, looking west</td>
<td>91</td>
</tr>
<tr>
<td>FIGURE 21</td>
<td>Cross section through Red Cloud mine, looking north</td>
<td>92</td>
</tr>
<tr>
<td>FIGURE 22</td>
<td>Principal workings of Black Rock Mine</td>
<td>95</td>
</tr>
<tr>
<td>FIGURE 23</td>
<td>Geologic map, Castle Dome district, Yuma County (1930)</td>
<td>100</td>
</tr>
<tr>
<td>FIGURE 24</td>
<td>Flora Temple mine, plan of part of workings, main shaft and 200 level as of 1930</td>
<td>107</td>
</tr>
<tr>
<td>FIGURE 25</td>
<td>Senora mine, plan of principal workings as of 1930</td>
<td>109</td>
</tr>
</tbody>
</table>
ARIZONA ZINC AND LEAD DEPOSITS—PART II
CHAPTER I—INTRODUCTION
BY ELDRED D. WILSON

SCOPE OF REPORT

This bulletin, which constitutes the second part of a general report on zinc and lead deposits in Arizona, is limited in scope to twelve districts, as noted on Figure 1 and pages 8, 9. The Arizona Bureau of Mines Bulletin No. 156, Arizona Zinc and Lead Deposits—Part I, published in 1950, dealt with ten districts (see Figure 1 and page 10). Descriptions of other districts and mines are being prepared for subsequent publication.

Appreciative acknowledgment is made to the mining companies, operators, and individuals who have furnished information.

PRODUCTION SUMMARY

Arizona ranked second in zinc and fourth in lead production within the United States for 1949, and third in zinc for 1950, according to figures released by the U.S. Bureau of Mines.

Of the approximately $4,743,781,000 value of all mine output in Arizona prior to 1951, zinc constituted 2.43 per cent, and lead 1.78 per cent. In 1950, zinc amounted to 8.47 per cent, and lead 3.26 per cent of the total mineral production of the State for the year.

Zinc supplanted gold as Arizona's second most valuable metal product during 1944-50, and lead took third place over silver during 1945-50.

The production of zinc and lead in Arizona during 1949 and 1950 has been reported by the U.S. Bureau of Mines as follows (figures for 1950 are preliminary):

<table>
<thead>
<tr>
<th>Years</th>
<th>Zinc Pounds</th>
<th>Zinc Price</th>
<th>Zinc Value</th>
<th>Lead Pounds</th>
<th>Lead Price</th>
<th>Lead Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949</td>
<td>141,316,000</td>
<td>$0.124</td>
<td>$17,523,184</td>
<td>67,136,000</td>
<td>$0.158</td>
<td>$10,607,488</td>
</tr>
<tr>
<td>1950</td>
<td>121,300,000</td>
<td>0.139</td>
<td>16,860,700</td>
<td>52,160,000</td>
<td>0.125</td>
<td>6,520,000</td>
</tr>
</tbody>
</table>

The 1949 output by counties is given by the U.S. Minerals Yearbook as follows:

<table>
<thead>
<tr>
<th>County</th>
<th>Zinc Pounds</th>
<th>Zinc Value</th>
<th>Lead Pounds</th>
<th>Lead Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cochise</td>
<td>75,851,500</td>
<td>$9,405,586</td>
<td>30,152,500</td>
<td>$4,764,095</td>
</tr>
<tr>
<td>Yavapai</td>
<td>31,040,000</td>
<td>3,848,960</td>
<td>7,360,500</td>
<td>1,162,959</td>
</tr>
<tr>
<td>Pinal</td>
<td>10,522,000</td>
<td>1,304,728</td>
<td>14,273,000</td>
<td>2,255,134</td>
</tr>
<tr>
<td>Pima</td>
<td>14,386,500</td>
<td>1,783,926</td>
<td>8,496,500</td>
<td>1,342,447</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>7,075,000</td>
<td>877,300</td>
<td>3,501,500</td>
<td>553,237</td>
</tr>
<tr>
<td>Graham</td>
<td>1,565,000</td>
<td>194,060</td>
<td>7,541,000</td>
<td>401,478</td>
</tr>
<tr>
<td>Mohave</td>
<td>860,500</td>
<td>106,702</td>
<td>333,500</td>
<td>52,693</td>
</tr>
<tr>
<td>Yuma</td>
<td>15,000</td>
<td>1,860</td>
<td>268,000</td>
<td>42,344</td>
</tr>
<tr>
<td>Gila</td>
<td>188,000</td>
<td>29,704</td>
<td>1,300</td>
<td>205</td>
</tr>
<tr>
<td>Maricopa</td>
<td>500</td>
<td>62</td>
<td>20,200</td>
<td>3,192</td>
</tr>
<tr>
<td>Greenlee</td>
<td></td>
<td></td>
<td>1,300</td>
<td>205</td>
</tr>
</tbody>
</table>

Production for earlier years is summarized in the Arizona Bureau of Mines Bulletin No. 156.
**Figure 1.**—Index map showing distribution of Arizona zinc and lead districts. List on pages 8, 9.

### DISTRICTS

The Arizona zinc and lead districts indicated on Figure 1 are as follows:

<table>
<thead>
<tr>
<th>Index Map No.</th>
<th>District or Locality</th>
<th>City or Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bisbee (Warren)</td>
<td>Chiricahua (Hilltop, California)</td>
</tr>
<tr>
<td>2</td>
<td>Tombstone</td>
<td>Dos Cabezas</td>
</tr>
<tr>
<td>3</td>
<td>Johnson (Cochise)</td>
<td>Huachuca (Hartford)</td>
</tr>
<tr>
<td>4</td>
<td>Turquoise (Gleeson, Courtland)</td>
<td>Golden Rule</td>
</tr>
<tr>
<td>5</td>
<td>Abril, San Juan</td>
<td>Oro Blanco (Ruby)</td>
</tr>
<tr>
<td>6</td>
<td>Swisshelm</td>
<td>Harshaw</td>
</tr>
<tr>
<td></td>
<td>Arizona Zinc and Lead Deposits</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Patagonia</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Tyndall</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Wrightson</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Palmetto</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Nogales</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Pima (San Xavier, Twin Buttes, Sierritas)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Empire</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Silver Bell</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Waterman</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Rosemont (Helvetia)</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Arivaca</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Amole</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Greaterville</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Papago</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Cerro Colorado</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Comobabi (Cababi)</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Old Yuma (Amole)</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Busterville</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Control (Old Hat)</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Gunsight (Meyer)</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Aravaipa</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Stanley</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Metcalf</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Old Hat (Mammoth, Tiger)</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Superior (Pioneer)</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Ray (Mineral Creek)</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Bunker Hill (Copper Creek)</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Mineral Hill (Cottonwood)</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Martinez Canyon</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Casa Grande (Vekol)</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Oracle (Catalina, Old Hat)</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Saddle Mountain</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Banner</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Globe</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Pioneer (Pinal Mountains)</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Dripping Spring</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Osborn, (Big Horn)</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Vulture</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Sunflower</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Castle Dome</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Silver</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Eureka</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>Plomosa</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>Bouse (Plomosa)</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Neversweat</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>Big Bug</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>Jerome (Verde)</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Eureka (Bagdad)</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>Hassayampa</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>Pine Grove, Tiger</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>Walker</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>Black Canyon</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>Copper Basin</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>Peck</td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>Turkey Creek</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>Castle Creek</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>White Picacho</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Wallapai (Chloride, Cerbat)</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>Cedar Valley</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>Owens (Mccracken)</td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>Maynard</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>Gold Basin</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>Havasu Canyon (Supai)</td>
<td></td>
</tr>
</tbody>
</table>
Described in this Bulletin

Index Map No. 4—Gleeson, Courtland
5—Abril, San Juan
6—Swisschelm
9—Huachuca (Hartford)
10—Golden Rule
11—Oro Blanco (Ruby)
19—Empire
39—Bunker Hill
45—Banner
52—Castle Dome
53—Silver
54—Eureka

Described in Arizona Bureau of Mines Bulletin No. 156

1—Bisbee
3—Johnson
18—Pima
33—Aravaipa
36—Old Hat (Mammoth)
37—Superior
46—Globe
58—Big Bug
60—Eureka (Bagdad)
70—Wallapai

Described in Arizona Bureau of Mines Bulletin No. 143

2—Tombstone

Described in Arizona Bureau of Mines Bulletin No. 145

70—Wallapai

CHAPTER II—DRAGOON MOUNTAINS

By Eldred D. Wilson

SITUATION AND ACCESS

The Dragoon Mountains are in central Cochise County, between the San Pedro and Sulphur Spring valleys. Dragoon station, on the Southern Pacific railway, is in a pass between the northwestern end of the main mountain range and the Little Dragoons north of it. The formerly active mining towns of Courtland and Gleeson are on the southeastern margin of the main range, about 15 miles east of Tombstone. Roads from Tombstone, Dragoon, and the Sulphur Spring Valley serve the principal mines.

TOPOGRAPHY

The Dragoon Range trends northwesterly, with a length of approximately 26 miles and a width of 3 to 12 miles. Its crest rises 1,000 to 3,000 feet above the adjacent plains and attains a maximum altitude of 7,512 feet above sea level. Its slopes are
characteristically steep, and the northern portion in the vicinity of Cochise Stronghold is extremely rugged.

Topography of the Dragoon Mountains has been mapped by the U.S. Geological Survey on the Pearce, Benson, Cochise, and Dragoon quadrangle sheets.

ROCKS

In generalized columnar section, the rocks in the Dragoon Mountains resemble those of the Tombstone, Johnson Camp, and Swisshelm (Fig. 7) areas.

Schist, probably of older pre-Cambrian age, crops out immediately west of Courtland and also on the west slope in the vicinity of South Pass.

North of the schist area on the west side of the range is a small exposure of dark greenish porphyritic granite carrying numerous schist fragments.

Bolsa quartzite of Middle Cambrian age overlies the schist and granite in the central and northern portions of the range and at Courtland. Because of faulting, intrusion, and erosion, its maximum observed thickness of 325 feet does not represent its total.

Overlying the Bolsa quartzite is the Upper Cambrian Abrigo limestone which on the southwest side of the range has an exposed thickness of approximately 400 feet. In places about 50 feet of yellow and red sandy shale, possibly equivalent to the Cochise formation, separates the Abrigo from the Bolsa.

Above the Abrigo is Devonian Martin limestone which has been recognized chiefly in the southwestern part of the area. There it has a maximum thickness of 355 feet.

The Mississippian Escabrosa limestone is characterized by medium to massive beds which, if metamorphosed, tend to form crystalline, relatively pure marble. It shows a thickness of 300 feet in the southwestern part of the range and occurs prominently in the Courtland area.

Pennsylvanian Naco limestone constitutes part of Gleeson Ridge, and Naco limestone of Snyder Hill (Permian) aspect is widespread in the main range. These limestones are medium to thin bedded, the Pennsylvanian is somewhat cherty, and the Permian is locally impure.

A series, from 1,000 to possibly 3,000 feet thick, of shale, sandstone, and basal conglomerate unconformably overlies the Paleozoic rocks, chiefly in the middle segment of the range and north of Courtland. It has been correlated tentatively with the Lower Cretaceous (Comanchean) Bisbee group.

Intruding the Cretaceous and older rocks is the Stronghold granite which occupies an area of more than 50 square miles in the northern portion of the range and extends as irregular masses and great dikes into the older formations. In the southern third of the area, granitic rocks also make up large areas. At Courtland and Gleeson they include quartz monzonite, quartz-mon-
zonite porphyry, and granite, all of post-Paleozoic age. Dikes of aplitic, rhyolite porphyry, felsite, and diabase are common locally.

The relation of the granitic intrusive rocks to mineralization is suggested particularly at the Abril, San Juan, Gleeson, and Courtland mines, which are relatively near to such intrusive masses.

Volcanic rocks, chiefly rhyolite or latite, occur in the vicinity of Courtland and Gleeson, and an extensive area of volcanics forms the southwestern corner of the range. These rocks have been regarded by Gilluly\(^5\) and others as Tertiary (?), but they might be Cretaceous; in South Pass andesitic flows occur interbedded with Cretaceous strata.

STRUCTURE

The structure of this region has been studied in considerable detail by James Gilluly, of the U.S. Geological Survey, but of his results only the following abstract has been published:\(^5\)

In the Dragoon Mountains, pre-Cambrian schists and intrusives are overlain by a Paleozoic section, essentially conformable Cambrian to Permian. These rocks were deformed and invaded in pre-Cretaceous time. The irregular erosion surface later formed was buried by Comanche (lower Cretaceous) sediments. Tertiary (?) volcanics unconformably overlie the Comanche.

The principal deformation was post-volcanic. Large thrusts carried the older rocks eastward over the Comanche and volcanics. At the south end of the range there are thick masses composed of individually thin plates of rocks of all ages, interleaved without regard to normal stratigraphic relationships; they are probably gigantic breccias along the erosion surface overridden by the major thrust. The probable root of the thrust is here occupied by intrusive felsite. Farther north, both this breccia and the postulated overlying thrust block have been eroded away, but the Cretaceous rocks are overturned to low dips for nearly 4 miles across the strike and are cut off on the west by steeply dipping thrust sheets of Paleozoic rocks. In the middle of the range at least three such thrusts occur. Farther north a large post-thrust granite has engulfed several square miles of the thrust masses and possibly domed them slightly. The north end of the range exposes only rocks above the basal thrust.

Northwest-trending normal faults (Pliocene?) cut all the older structures.

As described by Cederstrom,\(^1\) the middle segment of the range exhibits low-angle faulting, broad open folds, and steep reverse faults. The low-angle overthrusts, probably acting from the southwest, caused lower Paleozoic rocks to override Mesozoic and upper Paleozoic strata. The principal folds trend northwestward, but their continuity in that direction has been obliterated by subsequent granitic intrusion. Reverse faults of northwestward trend and steep southwest dip separate some of the folds and presumably influenced emplacement of the southeastward-trending tongues of granite. Northeast cross faults have displaced the earlier structures.

HISTORY OF MINING

Mineral deposits were discovered in the Dragoon Mountains during the seventies. Construction of the Southern Pacific rail-
way eastward through Dragoon Pass in 1881 greatly stimulated development.

Prior to 1895, mining was largely for precious metals. Copper mining then became important; it was particularly active after construction of railways into Courtland and Gleeson from Douglas and Cochise in 1909, but declined into minority after 1930. As statistics of production prior to 1907 are not available, the total output of lead and silver is not accurately known. Zinc ore shipments began in 1926.

All mining activity in the area became depressed after 1928, and the value of annual output remained under $100,000 until 1946.

During recent years the yield of zinc, copper, and lead has been considerably augmented by development of the Abril and San Juan mines.

**PRODUCTION**

<table>
<thead>
<tr>
<th>Metal</th>
<th>Years</th>
<th>Amount</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>1898-1949</td>
<td>33,677,000 lb.</td>
<td>$9,314,700</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38,472 oz.</td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td>1883-1949</td>
<td>1,198,660 oz.</td>
<td>805,170</td>
</tr>
<tr>
<td>Silver</td>
<td>1893-1949</td>
<td>7,018,600 lb.</td>
<td>831,057</td>
</tr>
<tr>
<td>Zinc</td>
<td>1926-49</td>
<td>6,014,343 lb.</td>
<td>441,900</td>
</tr>
<tr>
<td>Lead</td>
<td>1907-49</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total value</td>
<td>$12,035,977</td>
</tr>
</tbody>
</table>

The principal sources of this production have been as follows:
- Copper: Courtland, Gleeson, Black Diamond, Abril, Middlemarch.
- Gold: Gleeson, Courtland, Golden Rule.
- Silver: Gleeson, Courtland, Middlemarch, Abril, San Juan, Black Diamond.
- Zinc: Abril, San Juan, Gleeson, Courtland, and small mines principally in northern part of range.
- Lead: Gleeson, Golden Rule.

**GLEESON AND COURTLAND AREAS**

**Physical Features**

The Courtland-Gleeson or Turquoise district occupies an area about 4 miles long from north to south by 2 miles wide in the southeastern margin of the Dragoon Mountains, 15 miles east of Tombstone and 20 miles north of Bisbee.

The principal features of relief are two ridges of north-northwestward trend, fringed on the east by low foothills. The northern, Turquoise Ridge, is separated from the southern, Gleeson Ridge, by a narrow gulch. These ridges are each about 2 miles long by less than a mile wide, and they rise 900 to 1,200 feet above the adjacent plains. The principal mines are between altitudes of 4,700 and 5,200 feet.

**Structure**

Because of faulting and igneous intrusions, the structure at Gleeson and Courtland is highly complex.

Quartz monzonite and quartz-monzonite porphyry intrude the Paleozoic and older rocks but were not found affecting the Cretaceous. Granite and felsite cut the monzonites, and the granite invades the Cretaceous beds.
The strata of Turquoise and Gleeson ridges predominantly strike between N. and N. 30 degrees E. and dip steeply eastward, but locally they show considerable variations in altitude.

Low-angle faulting has moved pre-Cambrian schist, Bolsa quartzite, and Abrigo limestone over Carboniferous limestone at Courtland. Also, Bolsa quartzite overlies Pennsylvanian limestone southeast of Gleeson, and Pennsylvanian limestone is faulted onto Carboniferous (Permian ?) limestone in Gleeson Ridge (Fig. 2). Low-angle faults, bedding faults, and bedding slips are numerous in the area as a whole but may be inconspicuous at the surface. The overthrust plates commonly show folding.

Steeply dipping faults of general northerly and easterly trends are common in the district. Movement upon them has been both vertical and horizontal, and locally they displace the low-angle faults. The northerly faults in places swing northwestward, and the easterly faults range in strike from N. 65 degrees E. to S. 70 degrees E.

Later than the principal faults are northeast fissures of little or no displacement, which seem to be closely associated with mineralization. They are apparent in some of the mine workings but may be quite inconspicuous on the surface.

Ore Deposits

The principal ore deposits at Gleeson and Courtland are of copper, lead-silver, and zinc.

The copper deposits occur as (1) pyritic replacements and (2) oxidized replacements associated with low-angle faults. Those of the pyritic type contain some galena and sphalerite, but they have been worked comparatively little for lead and zinc. Most of the copper deposits of both these types are in the Courtland area, and some important pyritic replacements occur near the southwestern base of Gleeson Ridge.

The lead-silver and zinc deposits are replacements, chiefly in the Carboniferous limestone of Gleeson Ridge. They occur along steeply dipping faults and also beneath low-angle faults and bedding slips. Their localization generally seems to have been further influenced by northeast fissures.

Tom Scott Mine

The Tom Scott claim of the Tejon group is on the west slope of Gleeson Ridge. This claim, one of the early locations in the district, is reported to have produced some $50,000 worth of lead-silver ore during the eighties. During World War I it yielded about 2,500 tons of ore that averaged 7.5 per cent lead, 3.5 per cent copper, 20 ounces silver, and 0.11 ounces gold per ton. Further shipments of ore were made in 1919 and 1923, and in 1925 the output amounted to 4,000 tons. Intermittent production continued during 1926-33 and after 1942.

Here a prominent fault zone, marked by limonitic silicified breccia, dips steeply eastward and is traceable on the surface for 1,000 feet in a N. 12 degrees E. direction from the Tom Scott adit portal. Impure metamorphosed Permian (?) limestone forms its
footwall, and lighter colored Pennsylvanian limestone, more or less metamorphosed to marble, crops out east of it. Quartz monzonite intrudes the limestones on the south and west.

The ore bodies occur as irregular replacements associated with the main fault zone and probably related to transverse northeast fissures. Solution caverns and water courses are locally numerous, and some of them contain accumulations of oxidized ore.

The ore produced from this mine was oxidized and generally siliceous. In some stopes yellow limonitic materials of relatively high gold content predominated.

Workings in the Tom Scott mine include an adit level, driven northerly along the fault zone for more than 1,000 feet; five shorter levels above this adit, connecting with the surface; and some winze workings below the adit.

**Silver Bill Mine**

The Silver Bill claim of the Costello group is on the west slope of Gleeson Ridge, immediately north of the Tom Scott.

Rich silver-lead ore was mined from shallow workings on this claim during the eighties. The Silver Bill shaft was sunk about 1890. As evidenced by old stopes, considerable tonnages were mined prior to 1924. During 1922-24, F. J. Gibbons and M. Marchello, lessees, resorted part of the dump and shipped 150 to 900 tons of ore per month to El Paso; this ore averaged 10 per cent lead, a little copper, 3 per cent manganese, 10 ounces silver, and 0.075 ounces gold per ton. Lessees mined oxidized lead-silver ore and some oxidized zinc ore during 1925-29 and 1938-44.

Workings of the Silver Bill mine (Fig. 3) include an inclined shaft 271 feet deep, together with several hundred feet of drifts, winzes, and stopes. The bottom or 200 level connects with the Mystery adit.

The Silver Bill workings are within a relatively elevated block bounded on the north and south by two subparallel faults which strike N. 65 to 70 degrees E. and dip 65 to 80 degrees S. This block ranges in width from approximately 50 feet at the surface to 80 feet on the 200 (Mystery adit) level.

Extending northward through the collar of the shaft is an eastward- dipping fault, possibly a segment of the Tom Scott fault zone, which separates Pennsylvanian limestone on the east or hanging-wall side from impure Permian (?) limestone on the west. In the uppermost workings, this fault is roughly parallel to the bedding, but with depth it flattens and rolls as interpreted on Figure 2.

The principal ore body was stoped from the surface to a depth of 50 feet, with a north-south length of 35 to 50 feet and a thickness of 10 to 30 feet. It occurred to the impure limestone, immediately beneath the eastward-dipping fault (Fig. 2).

From a winze below the 200 level, an ore body was stoped for a depth of 60 feet, a length of 40 to 50 feet, and a width of 6 to 40 feet. It occurred along a northeast fissure which dips 70 degrees NW.
Figure 2.—Cross section of Gleeson Ridge through Silver Bill and Mystery mine stopes, looking N. 30 degrees W.
Some narrower and smaller ore shoots, associated with the faults of N. 65 to 70 degrees E. trend, were mined above the 200 level.

Downward from a point about 20 feet above the adit level, the ore is notably high in zinc content. According to A. P. Giacoma,\(^9\) two carloads shipped from the winze workings below the 200 level averaged 32 to 34 per cent in nonsulfide zinc and 1.5 to 2.0 per cent in copper. Similar ore, 10 or more feet wide, continued below the bottom of that stope.

Ore minerals include cerussite, anglesite, cerarygryrite, smithsonite, hemimorphite, hematite, limonite, jarosite, malachite, azurite, melaconite, aurichalcite, pyrolusite, and wulfenite.

**Mystery Mine**

The Mystery group of four patented claims, held in 1950 by D. L. Roscoe and S. Pryor, adjoins the Silver Bill on the east. Workings of the Mystery mine connect with an adit which opens on the east side of Gleeson Ridge and joins the lower level of the Silver Bill (Figs. 2 and 3).

Most of the Mystery workings were driven during 1923-24 by Mystery Mining Company. Production from the mine included 7,139 tons of oxidized lead-silver ore during 1924-25 and several thousand tons during 1926-30 and 1942. Fifteen or more carloads of high-grade oxidized zinc ore were shipped in 1926.

At the adit portal, impure dark-gray Permian (?) limestone, dipping steeply southeastward, is intruded by quartz monzonite which, a short distance farther east, is in turn intruded by quartz-monzonite porphyry. The intrusive contact between the quartz monzonite and the limestone, as exposed in the adit, dips 5 degrees westward (Fig. 2).

About 75 feet above the adit portal, the Permian (?) limestone is overlain by Pennsylvanian marble and limestone; the contact is a fault which here dips 20 degrees SW., roughly parallel to the overlying beds. In the first drift south from the adit and likewise in the stopes above, the Permian (?) is separated from the overlying marble by an arching fault. As indicated on Figure 2, these fault contacts between the Permian (?) and Pennsylvanian beds are believed to represent a continuation of the Silver Bill structure.

Oxidized lead-silver ore occurs in the impure limestone beneath this fault. It formed an irregular body that, as stoped, was 10 to 30 feet high and approximately 150 feet long by a maximum of 60 feet wide (Fig. 3). This ore body, of which a cross section is shown in Figure 2, trends along zones of fissures striking N. 45 to 50 degrees E. It is bounded on the north and south by faults that strike N. 65 to 70 degrees E., dip steeply southeast, and bring relatively barren marble down against the productive beds. These two faults are in alignment with, and probably continuations of, the faults which bound the Silver Bill block. In the Mystery the northern fault shows mineralization where cutting the impure limestone, but it is tight and inconspicuous in the marble. Typical
Figure 3.—Sketch map of Silver Bill and Mystery workings as of 1925.
ore from this stope is reported to have contained 20 per cent lead, 15 ounces of silver, and 0.2 ounces of gold per ton.

**Defiance Mine**

The Defiance claim of the Costello group is immediately west of the Silver Bill, on a southwest slope of Gleeson Ridge. This claim has been worked intermittently since the early days. During 1923-24 it yielded about 300 tons of ore that contained 8 to 14 per cent lead, a little zinc, and 4 to 7 ounces of silver per ton. Considerable tonnages were mined by lessees during 1939-44.

Here metamorphosed impure Permian (?) limestone dipping 40 degrees eastward is separated from marble on the north by a fault that strikes N. 80 degrees E. and dips 55 to 60 degrees northward. This fault is of the same general east-west system as the boundary faults within the Mystery and Silver Bill mines. In the Defiance workings it intersects a fault that strikes northwestward and dips 60 degrees NE., flattening upward.

The Defiance workings include an adit level with some 440 feet of drifts and two winzes, each 100 feet deep.

Oxidized ore, associated with abundant limonite, occurred as irregular replacements of the impure limestone in the hanging wall of the northwest fault, from the marble-fault contact on the north to an easterly fissure 50 feet south of the marble. This ore body ranged from 5 to 20 feet wide and in places was stoped from the surface to a depth of approximately 135 feet.

In the marble, 50 to 60 feet north of its fault contact, there were found two fissures with abundant gouge, striking N. 85 degrees E. and dipping 55 to 60 degrees N. Along them were replacement bodies about 5 feet wide, chiefly of limonitic material which in places contain hore silver together with low percentages of lead and zinc. According to James Giacoma, four tons of this ore mined by him contained 3,000 ounces of silver per ton.

**Dragoon Workings**

The Dragoon claim of the Costello group is immediately west of the Defiance. It was opened many years ago by irregular near-surface workings. During 1948 A. P. Giacoma was driving an adit to intersect the ore zone and had shipped a car of oxidized ore that contained about 10 per cent lead, 6 per cent zinc, 8 ounces of silver, and $1.25 in gold per ton.

Here the lower southern slope of the ridge consists of dark impure Permian (?) limestone dipping 20 to 35 degrees eastward. It is separated from marble on the north by a fault that strikes N. 80 degrees E. and dips 50 degrees N. It is intersected and offset slightly by steeply dipping faults of northerly to northwesterly strike. The impure limestone beds are cut by at least one slip that dips about 35 degrees northward.

Ore occurs with masses of iron oxide replacing the impure limestone chiefly along the easterly fault. There it has been stoped over a width of 5 to 10 feet and a length of 75 feet to a depth of 60 feet below the surface. Other replacements were found
beneath the northward-dipping low-angle slip, associated with tight northeast fissures.

**LAST CHANCE OR 1907 MINE**

The Last Chance mine, formerly known as the 1907, is on the northern slope of Casey Hill, approximately ½ mile northwest of Courtland.

Work in this area was started many years ago, and some oxidized zinc ore from the 1907 mine is reported to have been shipped to Kansas for paint manufacture. In 1949 the Last Chance claim was held by A. G. Stevenson and leased by D. F. Morris who shipped from it nine carloads of sulfide ore that contained an average of 19 per cent zinc and 7 per cent lead, together with a little gold and silver.

In this portion of Casey Hill, the principal rock is medium-bedded gray Naco limestone which in places includes lenses of chert and layers of shale or hornfels. Monzonite porphyry irregularly intrudes the limestone.

The beds dip prevailingly eastward but locally are deformed by flexures, low-angle faults, and steeply dipping faults.

An old shaft, reported to be 100 feet deep and with approximately 75 feet of southwesterly drift, passed from limestone into porphyry at a depth of 30 feet. Stopes beginning near the surface immediately west of this shaft extend southward in limestone beneath a low-angle fault or bedding slip which dips irregularly but locally forms a low anticlinal structure. These workings are limited on the north and south by steeply dipping faults of eastward trend.

The ore body stoped in 1949 occurred near the south boundary fault and ranged in thickness from 1½ feet on the north to 10 feet on the south. It contained sphalerite together with pyrite and subordinate galena.

**CENTRAL DRAGOON MOUNTAINS AREA**

**SAN JUAN OR GORDON MINE**

**Situation:** The San Juan or Gordon group of fourteen claims is the west-central part of the Dragoon Range, about half a mile south of China Peak. This area is accessible by 3 miles of road that branches north from the Middlemarch or Abril road at a point 14 miles northeast of Tombstone.

**History:** The San Juan property has been held for many years by Jonathan Gordon. Development prior to 1947 included more than 1,000 feet of workings, largely within the Sulphide and Silver connecting adits. Some zinc ore was shipped during 1913-15 and 1925.

In 1947 Operations, Inc., leased the ground, constructed 3 miles of access road, and erected at Tombstone a concentration plant of 100 tons daily capacity. This company suspended production before the end of that year. Billingsley Machinery Company bought the mill and in September, 1948, reopened the mine. When visited in March, 1949, more than 15,000 tons of ore had been mined and milled in the preceding six months. The property closed down in
May, 1949, owing to the drop in the price of zinc.\textsuperscript{11} In June, 1951, Mr. Gordon was reported to have resumed work at the mine, and Lomelino Mineral Development Company had purchased the mill at Tombstone.\textsuperscript{12}

**Production:** Available production figures, as compiled from the U.S. Minerals Resources volumes and U.S. Minerals Yearbooks, are as follows:

<table>
<thead>
<tr>
<th>Years</th>
<th>Tons of ore</th>
<th>Pounds of zinc</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1913</td>
<td>?</td>
<td>36,503</td>
<td>$2,044</td>
</tr>
<tr>
<td>1914</td>
<td>?</td>
<td>39,324</td>
<td>2,006</td>
</tr>
<tr>
<td>1915</td>
<td>?</td>
<td>63,386</td>
<td>7,860</td>
</tr>
<tr>
<td>1925</td>
<td>48</td>
<td>32,592</td>
<td>2,477</td>
</tr>
<tr>
<td>1947</td>
<td>4,000</td>
<td>639,800</td>
<td>77,416</td>
</tr>
<tr>
<td>1913-47</td>
<td></td>
<td>811,605</td>
<td>$91,803</td>
</tr>
<tr>
<td>1948</td>
<td>2,584</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

Figures regarding the amount of zinc recovered in 1948 and 1949 are not reported.\textsuperscript{11}

Ore shipped in 1915 carried 40 per cent zinc and 8.5 ounces of silver per ton.\textsuperscript{13} The 1947 output of zinc ore is reported to have contained less than 1 per cent lead and less than 2 ounces of silver per ton. According to W. M. Shaw, mine superintendent in 1949, several thousand tons of ore mined immediately prior to March of that year averaged about 1 per cent lead.\textsuperscript{9}

**Geology:** The San Juan mine is on the west side of a southeastward-trending gulch, at an altitude of approximately 6,400 feet. Some of the geologic relations are shown in Figure 4.

In the ridge at the mine, the following succession of rocks, from lowest to highest, is exposed: Quartzite, light-colored and fine grained, of Permian aspect, approximately 60 feet thick; gray shale, in part siliceous or novaculitic, with some impure limestone beds, locally metamorphosed to epidote, garnet, and other silicates (tactite), approximately 40 feet; bluish-gray limestone conglomerate and limestone, separated from underlying beds by low-angle fault, approximately 30 feet; thin-bedded dark to brownish shale, in part sandy, caps eastern slope of ridge. Presumably the conglomeratic limestone and overlying shale are Cretaceous.

In the mine workings, the prevailing southeastward dip of the beds is modified by broad, low flexures. Also, faults which trend N. 30 degrees W. and N. 70 degrees E. have effected relatively small displacements.

The side gulch immediately south of the mine apparently marks the location of a fault trending N. 65 to 70 degrees W. and with its northern side downthrown. South of it is exposed siliceous gray shale interbedded with cherty gray limestone and capped by fine-grained light-colored quartzite. Near the supposed fault in the side gulch, these beds dip steeply north, but within a short distance southward they flatten to low dips.

The main gulch east of the mine presumably marks a fault of northward trend, with its west side downthrown as indicated in Figure 4.

Granite invades the sedimentary series on the west (Fig. 4).
Figure 4.—Cross section of ridge at San Juan mine, looking north.
Workings: The San Juan mine workings are chiefly from adit levels. The silver adit extends northward and connects with the sulfide adit which extends west and southward. These two tunnels, together with their drifts and stopes, are distributed through an area approximately 330 feet long by 100 feet wide. In addition, there is the Mistletoe adit (Fig. 4) with approximately 200 feet of workings, and several shorter adits.

Ore deposits: Replacing the impure shaly limestone beds beneath the conglomeratic limestone in the San Juan mine are irregular masses of contact silicates, chiefly garnet, hedenburgite, and epidote. The ore minerals, which consist of sphalerite and subordinate galena together with erratically distributed silver in unrecognized form, occur associated with the contact silicate minerals, hematite, and calcite.

The known ore bodies occur beneath the low-angle fault shown on Figure 4, along zones of northeast fissures. The principal stope extended northeastward with a length of 180 feet, a maximum width of 90 feet, and a height of 3 to 20 feet. In March, 1949, ore was being mined from the Mann adit, 30 feet east and 37 feet below the Silver adit.

Abriel Mine

Situation: The Abril mine is 2 miles in air line north of the San Juan mine or 21 miles from Tombstone via the Middlemarch road and Sorens Canyon. During winter, this road may be blocked by snow for short periods.

A lower haulage route via Slavin Gulch, branches north from the Middlemarch road near Sala’s ranch and terminates at the ore bins and tramway a few hundred feet down the slope west of the camp.

History: In 1943 the Abril was an undeveloped prospect, held by the Abril Brothers and H. W. Smith, of Tombstone. During that year W. Sim and Mrs. H. Miller, lessees, obtained an R.F.C. loan of $15,000 upon the property. In 1944 it was operated in a small way by Adrion Skinner and Dan Lewis, lessees. During part of 1945, the mine was worked under lease by Bargain Mines, Inc., which shipped 1,614 tons of zinc ore to the Shattuck Denn mill at Bisbee.

In December, 1945, the property was taken over under option by Shattuck Denn Mining Corporation, which subsequently carried on extensive underground development, together with core drilling, and maintained intermittent production until the drop of metal prices in 1949. Early in 1951 the mine was being worked under lease by Sherwood Owens.

Production: The zinc output of the Abril mine, as reported in the U.S. Minerals Yearbooks, has been as follows:

<table>
<thead>
<tr>
<th>Years</th>
<th>Ore Tons</th>
<th>Zinc Lb. contained</th>
<th>Zinc Lb. recovered</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1945</td>
<td>1,614</td>
<td>no data</td>
<td>500,000</td>
<td>57,500</td>
</tr>
<tr>
<td>1946</td>
<td>7,123</td>
<td>no data</td>
<td>1,523,000</td>
<td>185,806</td>
</tr>
<tr>
<td>1947</td>
<td>9,990</td>
<td>2,435,910</td>
<td>no data</td>
<td>no data</td>
</tr>
<tr>
<td>1948</td>
<td>1,214</td>
<td>no data</td>
<td>no data</td>
<td>no data</td>
</tr>
</tbody>
</table>
Figures regarding the other metals are not reported, except that the 9,990 tons milled in 1947 contained, in addition to the zinc, 188,162 pounds of copper, 12,725 pounds of lead, 3,508 ounces of silver, and 26 ounces of gold.11

Topography: The Abril mine is on the western slope of the Dragoon Mountains, at an altitude of approximately 6,600 feet or a few hundred feet below the crest of the range.

This terrane is characterized by steep slopes, very rugged where on granite but comparatively regular where on sedimentary beds. The area is drained southwestward by deep canyons tributary to Slavin Gulch.

Rocks: The top of the ridge east of Abril Camp consists of fine-grained light-colored quartzite approximately 80 feet thick. It is overlain, on the eastern backslope, by a thick series of metamorphosed, locally foliated shale and arkosic sandstone.

Underlying the quartzite is limestone, approximately 570 feet thick. Its upper portion consists of massive, locally cherty beds which are largely metamorphosed to marble. Its lower portion, 70 feet thick, is made up of impure, shaly limestone, locally converted to contact-silicate minerals (tactite).

Underlying the limestone is arkosic quartzite with a maximum observed thickness of 100 feet. It is underlain, with intrusive contact, by granite.

Fine-grained, light-colored arkosic quartzite, commonly 25 to 100 feet thick, underlies the limestone and rests upon the intrusive Stronghold granite.

The two quartzite members and the limestone between them are regarded as Permian.

A sample of the Stronghold granite intrusive, collected from the No. 5 adit of the Abril mine, is described by R. T. Moore, of the Arizona Bureau of Mines, as follows:

Microscopically the rock is an equigranular aggregate of quartz and feldspar with minor amounts of biotite and muscovite. The feldspar consists of orthoclase, albite, microperthite, and oligoclase. Average grain diameter is about 0.04 inch, although for a few phenocrysts of the potash feldspar it is 0.2 inch. Small amounts of magnetite are present. Minor amounts of sericite and a clay mineral have developed, apparently in the albite.

Structure: The sedimentary beds at the Abril mine dip northeastward at angles of 25 to 50 degrees from horizontal.

Underground exploration has shown that the Stronghold granite intrudes the lower quartzite subparallel to its bedding (Fig. 6). A northeastward-trending dike of the granite 175 to 300 feet wide cuts the sedimentary beds immediately north of adit No. 5 (Fig. 5). Near this dike the beds have been complexly faulted and sharply folded.

As indicated on Figure 5, a fault dipping 50 to 60 degrees northeastward strikes N. 30 to 45 degrees W. through the portal of adit No. 3, bringing quartzite on the southwest against limestone on the northeast.
Figure 5.—Generalized map of Abril mine. (Plan of workings from map furnished by Shattuck Denn Mining Corporation. Geology by Eldred D. Wilson. Structural details in southeastern stopes not shown.)
The mine workings show a prominent zone of bedding-plane faults which form the hanging wall of the stopes. It steepens, with low roll down the dip, from 25 degrees in the adit No. 1 workings to 45 degrees in adit No. 4 (Fig. 5). Northeast fissures of little or no displacement intersect these bedding-plane faults. Also there are a few minor breaks of northwestward trend, sub-parallel to the portal fault of adit No. 3.

**Workings:** The Abril mine workings (Fig. 5) are on five adit levels at successively lower elevations.

**Ore deposits:** The ore minerals found in the Abril mine are principally sphalerite and chalcopyrite, together with subordinate amounts of galena. Silver occurs in unrecognized form. Molybdenite and yellow molybdenum oxide are sparingly present. These minerals occur more or less closely associated with garnet, epidote, and other contact silicates.

The ore bodies are irregular replacements (Figs. 5 and 6) in impure beds within the lower 70 feet of the limestone. They are localized beneath the zone of bedding-plane faults, previously described, and occur associated with northeast fissures as indicated on Figure 5. These fissures tend to be inconspicuous, but some of them are marked by concentrations of iron oxides. Their association with the known ore bodies suggests the possibility that additional deposits may occur down the dip, northeast of the present stopes, in areas that have not been explored.

**Senecia Mine**

The Senecia mine is in the northeastern margin of the Dragoon Mountains, 9 miles northwest of Pearce. It is accessible by 3½ miles of road that branches northward from the Cochise Stronghold road near the base of the mountains.

In 1943, C. B. Lancaster and R. D. Brooks shipped from this mine to the Shattuck Denn mill, at Bisbee, 216 tons of ore that contained approximately 25 per cent zinc, 5 per cent lead, and 1.5 ounces of silver per ton.

Here the prevailing rock consists of metamorphosed siliceous Naco limestone which, less than ½ mile farther south, is intruded by the Stronghold granite.

The mine workings include an adit extending S. 30 degrees W., with some small stopes and short raises; and a shaft of undetermined depth at the portal. As of April, 1951, water stood in this shaft at a depth of 12 feet below the collar, and a small amount of water was issuing from the adit.

The workings are on the gently eastward-dipping flank of a low anticlinal roll in the limestone. Where exposed underground, the vein strikes south, dips 20 to 30 degrees E., and is intersected by a tight barren fracture along the back of the adit. Much of the vein is thin and weakly mineralized, but as indicated by small stopes at the adit face and near the portal, it becomes 1 to 5 feet thick where intersected by zones of inconspicuous northeast fissures. Apparently the ore consists largely of irregular small lenticular masses of sphalerite, together with pyrite and iron oxide, in brecciated wall rock.
Figure 6.—Generalized cross section through Abril mine stopes, looking east. (Courtesy of Shattuck Denn Mining Corporation.)
According to Mr. Lancaster, core drilling indicated ore mineralization 18 inches thick at a depth of about 10 feet below the adit portal.

**OTHER MINES IN CENTRAL DRAGOON AREA**

The *Escapule* mine, east of the San Juan, and the *Muheim* property are reported to have produced small quantities of zinc ore during the past 25 years.

**NORTHERN DRAGOON MOUNTAINS AREA**

**Golden Rule Mine**

The Golden Rule or Old Terrible mine is at the northeastern siding on the Southern Pacific railway.

This property was located during the late seventies. In 1883 the Tucson Star and U.S. Mint Report credited it with a production of $125,000 in gold. A yield of $30,000 was reported for 1884, after which the next recorded output was in 1891 when ore valued at $12,000 was shipped to Pinos Altos, New Mexico. In 1897 the mine was acquired by Golden Queen Consolidated Gold Mining Company which built a small mill. Intermittent production continued through 1902 during which period the company was reorganized or purchased by Old Terrible Mining Company. From 1905 to 1908, Manzoro Gold Mining Company operated the property. No work was reported for nine years afterward. Small intermittent production, largely by lessees, has continued since 1916. The property has been owned by Mrs. E. M. Jackson, of Benson, for many years.

Although known chiefly as a producer of gold, the Golden Rule was credited with an output of 320,000 pounds of lead prior to 1930, and with intermittent shipments of lead ore during recent years.

At the mine cherty, dolomitic limestone of the Cambrian Abrigo formation strikes N. 65 degrees W., dips 30 to 40 degrees north-eastward, and is intruded on the south by a small stock of granitic porphyry.

The principal production has come from the area of the Jackson inclined shaft. Here, stopes 2 or 3 feet thick extend from the surface to the first level for a few hundred feet northwest of the shaft and to generally shallower depths for some 200 feet southeast of the shaft. The vein dips parallel to the limestone beds and at places is offset by faults which strike N. 65 degrees E. Its filling consists of coarsely crystalline grayish white quartz, locally somewhat banded and brecciated, apparently about 18 inches in maximum thickness. In places it shows abundant vugs which contain hematite, limonite, calcite, cerussite, anglesite, galena, pyrite, and minor amounts of oxidized zinc minerals. The gold is reported to occur mainly in the iron oxides and to a small extent in the quartz. Several hundred tons of the ore mined during the few years prior to 1927 were reported to have contained an average of 0.62 ounces of gold and 2.3 ounces of silver per ton, 7.9 per cent lead, 2 per cent zinc, 75 per cent insoluble, 6 per cent iron, 2.5 per cent lime and 0.4 per cent sulfur.
In the porphyry area southeast of the Jackson shaft, a few shallow shafts have been sunk on a quartz vein, locally 1 to 2 feet wide, which strikes N. 65 degrees W. in approximate alignment with the Jackson workings and dips steeply northeastward. These shafts show narrow lenticular bodies of iron oxides with galena, oxidized lead minerals, and local copper stain, generally near the hanging wall.

**HUBBARD MINE**

The Hubbard mine is in the northwestern margin of the Dragoon Mountains, south of Fourr Canyon, approximately 5 miles by road southwest of Dragoon station. It was worked principally during 1943, 1944, and 1949 and is credited with a production of several hundred tons of zinc ore. The deposit consists of tabular replacements in complexly faulted limestone.

**REFERENCES, DRAGOON MOUNTAINS**


12. Oral communication from Freeman Lomelino.


CHAPTER III—SWISSHELM DISTRICT
BY F. W. GALBRAITH AND W. B. LORING

PHYSICAL FEATURES

The Swisshelm district is in the northern portion of the Swisshelm Mountains, about 30 miles north of Douglas.

Most of the lead mining area is within Twp. 20 S. R. 27E. It is accessible by 4 miles of road that branches southward from the Rucker Canyon road at a point 13 miles east of U.S. Highway 666.

The Swisshelm Mountains form a range about 15 miles long which extends north-northwest from the Chiricahua Mountains, on the east side of Sulphur Spring Valley. A small valley, about 5,500 feet above sea level or some 1,000 feet lower than the nearby peaks, trends northward through the mining area.

ROCKS

The geology of the Swisshelm Mountains was studied briefly by C. J. Sarle in 1922 for the Geologic Map of Arizona. In 1947 W. B. Loring\(^1\) made a geologic study of the Swisshelm mining district and determined the stratigraphic sequence as follows (see also Fig. 7):

<table>
<thead>
<tr>
<th>Age, formation and character</th>
<th>Thickness in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary</td>
<td></td>
</tr>
<tr>
<td>Rhyolite flows; lavender to red, massive</td>
<td>500+</td>
</tr>
<tr>
<td>Cretaceous</td>
<td></td>
</tr>
<tr>
<td>Morita formation; maroon shales, arkosic quartzites, and conglomerates</td>
<td>1,000</td>
</tr>
<tr>
<td>Permian</td>
<td></td>
</tr>
<tr>
<td>Snyder Hill formation; limestone, thin-bedded with red shales and conglomerate at the base</td>
<td>250</td>
</tr>
<tr>
<td>Pennsylvanian</td>
<td></td>
</tr>
<tr>
<td>Naco formation; medium-to-thin bedded limestone alternating with thin shale. Conglomerate at base</td>
<td>2,400</td>
</tr>
<tr>
<td>Mississippian</td>
<td></td>
</tr>
<tr>
<td>Escabrosa limestone; thick-bedded, white, and relatively pure</td>
<td>330</td>
</tr>
<tr>
<td>Devonian</td>
<td></td>
</tr>
<tr>
<td>Lower Ouray formation; limestones, thin black, shaly, and dolomitic</td>
<td>50</td>
</tr>
<tr>
<td>Martin limestone; thin-to-thick bedded, brown to gray, sandy</td>
<td>350</td>
</tr>
<tr>
<td>Cambrian</td>
<td></td>
</tr>
<tr>
<td>Copper Queen limestone; gray, sandy. Parting quartzite at top</td>
<td>175</td>
</tr>
<tr>
<td>Abrigo formation; interbedded limestone and shale, thin, cherty, and green</td>
<td>225</td>
</tr>
<tr>
<td>Cochise formation; interbedded limestone and shale, thin, cherty, and green</td>
<td>200</td>
</tr>
<tr>
<td>Bolsa quartzite; dense, medium-bedded, white</td>
<td>200+</td>
</tr>
</tbody>
</table>

The Cretaceous and older rocks are intruded by granite which crops out over much of the western portion of the range. Its age

\(^1\) References are listed numerically at end of chapter.
Figure 7.—Generalized columnar section, Swisshelm Mountains, Arizona. (By W. B. Loring.)
tentatively is considered as Laramide (late Cretaceous — early Tertiary).

Numerous small dikes of diorite cut the granite. A relatively thin, tabular mass of diorite porphyry crops out in the central part of the district.

STRUCTURE

The post-Cretaceous structural history of the Swisshelm Mountains includes intense folding, thrust faulting, and normal faulting. The sedimentary formations of the Swisshelm mining district represent the eastern flank of a sharply compressed anticline which plunges 15 degrees north-northwestward. The beds on the east flank have an average northeasterly dip of about 45 degrees. A body of granite has been intruded along the anticlinal axis and separates the eastern flank from the western flank, whose beds crop out in the foothill area to the west of the range and dip steeply to the southwest.

The structure of the eastern flank has been complicated by a low-angle thrust fault on which a plate of Upper Paleozoic rocks has been moved over the Lower Paleozoic rocks. The outcrop of this fault is highly irregular, but may be traced in a northwesterly direction across the central part of the district. It dips 10 to 15 degrees to the northeast. The beds in the overthrust plate have an average dip of about 35 degrees to the southwest.

In the northern part of the area several parallel thrust faults have resulted in a complex imbricate structure.

The main thrust fault has been intruded by a tabular body of diorite porphyry (Fig. 8) which ranges from 4 to 50 feet in thickness.

Where the porphyry is best exposed in the central part of the district, Cambrian rocks dipping eastward lie below the sill, and Pennsylvanian rocks dipping westward lie above it.

Along the western margin of the district is a normal fault which strikes north-northwest and dips 60 degrees to the northeast. It has brought Tertiary rhyolite on the northeast down against Paleozoic sedimentary rocks on the southwest. Loring estimated the vertical displacement at about 500 feet.

ORE DEPOSITS

Occurrence

The ore deposits of the Swisshelm district occur as replacements in Naco limestone. The most productive bodies of ore have been found in the beds immediately above the diorite prophyry. They were apparently localized by the intersections of northwesterly and northeasterly tension fractures with the favorable limestone beds.

Production

The Swisshelm district produced lead, silver, and gold at intervals during 1885-1918, but no figures regarding the output for that period are available.
Figure 8.—Cross section of Mountain Queen and Chance mine areas, looking north.

Production during 1918-49 has been approximately as follows:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Period</th>
<th>Quantity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead, 1918-49</td>
<td>9,271,217 pounds</td>
<td>valued at $1,117,930</td>
<td></td>
</tr>
<tr>
<td>Silver, 1918-49</td>
<td>244,780 ounces</td>
<td>$194,989</td>
<td></td>
</tr>
<tr>
<td>Gold, 1918-49</td>
<td>2,887 ounces</td>
<td>$96,211</td>
<td></td>
</tr>
<tr>
<td>Zinc, 1948-49</td>
<td>197,500 pounds</td>
<td>$25,306</td>
<td></td>
</tr>
<tr>
<td>Copper, 1926-49</td>
<td>48,318 pounds</td>
<td>$8,705</td>
<td></td>
</tr>
</tbody>
</table>

Total value, 1918-49: $1,443,141

The greater part of this output was during 1946-49.

Mountain Queen or Scribner Mine

Situation: The Mountain Queen or Scribner mine is in the northeastern part of the Swisshelm Mountains, approximately ½ mile south-southeast of U.S. Mineral Monument No. 1, at an altitude of 5,500 feet.

History and production: The deposit was discovered in 1885, and a small production of oxidized lead-silver ore was intermittently maintained until 1913. No production records are available for this period.

In 1913 the property was leased. Recorded production from 1918-26 is gold, $5,807; silver, $35,365; lead, $41,754.

In 1935, a well drilled for water near the east side of the Mountain Queen claim penetrated ore 25 feet thick at a depth of 125 feet. This ore was mined from a shaft on the Chance No. 1 claim. In 1941 a cave-in put an end to this operation. A production of $80,000 is reported for this period.

In 1945 the property was again leased and has been operated more or less continuously since that time. As of 1951, it was owned by Dr. Edwin Larson of Los Angeles, California. In 1947 a two-compartment shaft was completed on the Mountain Queen claim. The bulk of total ore taken from the mine was produced during 1947-49.

The total production from the Mountain Queen mine is not known, but it has accounted for the greater part of the output of the Swisshelm district.

Geology: The Mountain Queen mine is in the Pennsylvanian Naco formation, which consists of thin limestone beds alternating
with thin-bedded calcareous shale. In general the beds strike N. 35 degrees W. and dip 25 to 50 degrees SW.

The Naco formation is part of an overthrust plate of Paleozoic sedimentary rocks which is underlain by a tabular body of diorite porphyry (Fig. 8) intruded along the plane of the thrust fault. The horizontal compression which resulted in the thrust faulting also produced minor folds in the Naco formation, the axes of which trend northwesterly. Vertical tension fractures have formed parallel to the fold axes, and a series of fractures with northeasterly strike and steep dips have developed at right angles to the trend of the folds. Bedding slips with northwesterly strike and low northeasterly dips are also present.

*Ore deposits:* The ore bodies occur as replacements in the Naco formations at the upper contact with, or not far above, the diorite porphyry. Some of the individual ore bodies attain a length of 100 feet, a width of 50 feet, and a thickness of 10 or more feet.

On the 160 level the ore bodies occur along the axis of a minor fold which trends northward. Parallel and at right angles to the fold axis are several more or less vertical fractures. Also parallel to the fold axis is a bedding slip which dips 40 degrees northeasterward. The ore apparently occurs in an area where the axis of the fold, the northwest and northeast fractures, and the bedding slip intersect immediately above the diorite porphyry contact. This relationship suggests a definite structural control of ore deposition by thorough preparation of the more brittle limestone beds by fracturing or brecciation.

In the near-surface workings on the western edge of the Mountain Queen claim, ore deposition appears to have been controlled by high angle northeasterly trending fractures.

*Ore minerals from the 160 level are principally galena and cerussite with which is associated a little pyrite. In 1947 the average grade was reported to be 25 per cent lead with a sulfide-carbonate ratio of 1:4. The silver most probably is contained in the galena, as microscopic examination of the ore failed to reveal the presence of any silver mineral. In the old surface workings iron oxides are abundant, and cerargyrite probably was an important constituent of these ores.

The mine is developed to a depth of 210 feet by a shaft, adits, drifts and stopes, aggregating about 1,000 feet of work. The mine produces no water.

In June, 1951, according to C. W. Colvin,5 mine superintendent, underground development work was being carried on in the northern part of the mine.

**Chance Mine**

*Situation:* The Chance mine is in the northeastern part of the Swisshelm Mountains, a few hundred feet northeast of the Mountain Queen or Scribner mine.

*History and production:* The claims embracing the Chance mine were located in 1885 shortly after discovery of the Mountain Queen, but apparently no ore was found then on the property.
In 1915 a shallow inclined shaft was sunk near the northern end of the Chance group of claims, with negative results.

In 1935, following discovery of ore on the Mountain Queen claim, a shaft 116 feet deep was sunk on the Chance No. 1 claim and a drift run to the newly discovered ore body of the Mountain Queen. So far as is known, no ore was discovered on the Chance at that time.

In 1945 the lessees of the Mountain Queen and Chance claims jointly sank a new shaft 250 feet deep on the Chance No. 1, 220 feet southeast of the old shaft. A drift to the east on the 200 level penetrated ore.

The production from the Chance mine is not known, but it has been substantially less than that from the Mountain Queen or Scribner mine.

Geology and ore deposits: The Chance mine is in the same overthrust block of Pennsylvanian Naco formation (Fig. 8) as the Mountain Queen mine. The beds strike northwesterly and dip approximately 55 degrees southwestward. The overthrust block is underlain by the tabular body of diorite porphyry and is broken by a series of northeasterly trending fractures with steep dips.

Four ore bodies had been discovered up to the end of 1947. One of these, which had been mined out, was 50 feet long, 20 feet thick and 30 feet high. They are replacements of the limestone beds along or adjacent to fractures which strike north-northeast and lie immediately above the diorite porphyry contact. As in the Mountain Queen, the diorite porphyry is so altered that the fractures could not be definitely traced into it.

Ore minerals are galena and cerussite. A little pyrite occurs associated with the galena. In 1947 the average grade was reported to be 25 per cent lead and, in places, up to 28 ounces of silver and 0.2 ounces of gold per ton.

The mine is developed to a depth of 250 feet by a shaft, manway, drifts, and cross-cuts aggregating about 1,300 feet of work.

As of 1947, the mine workings yielded about 3,000 gallons of water per day.

Swisshelm Mountain Gold and Silver Mining Company

Situation: The property of the Swisshelm Mountain Gold and Silver Mining Company is approximately 2,000 feet northeast of U.S. Mineral Monument No. 1, or a mile northeast of the Scribner.

History and production: The Mammoth and Whale groups of claims were located in 1898. They were acquired in 1922 by Swisshelm Development Company, which completed an inclined shaft 300 feet deep and several hundred feet of drifting.

In 1947 Swisshelm Mountain Gold and Silver Mining Company acquired the claims.

The production from this property is not known.

Geology and ore deposits: The mine of Swisshelm Gold and Silver Mining Company is in the same overthrust block of Pennsylvanian Naco formation as the Mountain Queen and Chance mines. The beds strike northeasterly and dip about 30 degrees northwestward.
Mineralization consists of replacements in the Naco formation. It is principally of silver with some lead and gold, accompanied by quartz, calcite, and a little pyrite.

The mine is developed by an inclined shaft 300 feet deep on a 30-degree incline, an adit on the 75 level, 575 feet of cross-cuts, and 425 feet of drifting.

REFERENCES, SWISSHELM DISTRICT
3. Oral communication.

CHAPTER IV—HUACHUCA MOUNTAINS
BY ELDRED D. WILSON

PHYSICAL FEATURES

The Huachuca Mountains are in southwestern Cochise County, on the west side of the San Pedro Valley. They form a range approximately 22 miles long by a maximum of 8 miles wide which trends northwestward from the International boundary. The maximum altitude, 9,446 feet, is on Miller Peak, 4,500 feet above the eastern base of the range. The slopes are prevailingly steep and deeply dissected by canyons.

Topography of the Huachuca Mountains has been mapped by the U.S. Geological Survey on the Hereford and Benson quadrangle sheets.

The principal settlement is Fort Huachuca, at the northeastern base of the range. Ranches and summer homes are in several of the canyons, and a few people live at some of the mines. Hereford, a station on the Southern Pacific railway, is 9 miles east of the mountains.

The eastern margin of the range is skirted by State Highway 92, and its southern end is crossed by the Montezuma Canyon road. Access roads from these routes and from highways on the north and west lead to the mines.

ROCKS

The rocks of the Huachuca Mountains have been described in considerable detail by Alexis and Weber.

Bolsa quartzite rests upon pre-Cambrian granite and is overlain by limestones and shales of Cambrian, Devonian, Mississippian, Pennsylvanian, and Permian ages. Above the Permian is a thick succession of conglomerate, sandstone, quartzite, shale, and interbedded volcanic flows, of Lower Cretaceous age. These beds are unconformably overlain by Tertiary (?) volcanic rocks in the northwestern part of the range.

References are listed numerically at end of chapter.
Intruding the Cretaceous and older rocks is a northwestward-trending stock of quartz monzonite which crops out over an area 7 miles long by 2½ miles wide in the southern part of the range, between Montezuma Canyon and Carr Peak. Associated with it are dikes of andesite and quartz-latite porphyry.

STRUCTURE

As determined by Alexis' and Weber, the Huachuca Mountains area was successively deformed by folding, broken by thrust and reverse faulting, and subjected to normal faulting. In the east-central portion, according to Weber, six major thrust-fault systems were superimposed upon the northeastern limb of a regional anticlinal fold.

Folding was apparently initiated previous to thrust faulting, but continued with the development of successively younger thrusts northeastward from the anticlinal axis. Both fold axes and thrust faults strike persistently northwestward, generally paralleling the trend of the range. The thrusts dip prevailingly northeastward at low to high angles.

The development of minor anticlinal and synclinal folds apparently accompanied thrust faulting, in several places resulting in folding of the earlier thrust sheets. Overturned folds and drag folds were also companion features.

The observed major structural deformation apparently began in post-early Cretaceous time, and may have continued into the Tertiary.

The quartz monzonite is largely younger than the major deformation of the range.

ORE DEPOSITS

HISTORY AND PRODUCTION

Prospecting in the Huachuca Mountains began at an early date but was retarded by Apache hostilities until the establishment of Fort Huachuca in 1877. During the early eighties a little ore was sent from the Nellie James and other properties to lead smelters at Charleston and Benson.

Early in the present century, the Butte and Arizona, State of Texas, and Sitric were developed, and the Exposed Reef was worked as a gold prospect. The Eureka and Copper Glance mines were operated by a religious sect living at Sunnyside. The Wisconsin mines were developed by a company which in 1903 was managed by Harry Hamburg. Tungsten deposits were worked mainly during war years, and gold placers during periods of depression. Zinc and lead have been mined principally since the beginning of World War II.

Available figures regarding production of lead, zinc, copper, gold, and silver in the Huachuca Mountains (Hartford district) are as follows:

<table>
<thead>
<tr>
<th>Commodity</th>
<th>1909-49</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>558,685 lb., valued at $49,007</td>
</tr>
<tr>
<td>Zinc</td>
<td>348,000 lb.,</td>
</tr>
<tr>
<td>Copper</td>
<td>71,580 lb.,</td>
</tr>
<tr>
<td>Gold</td>
<td>388 oz.,</td>
</tr>
<tr>
<td>Silver</td>
<td>24,254 oz.,</td>
</tr>
<tr>
<td>Unspecified</td>
<td>(mainly lead and silver) 23,379</td>
</tr>
<tr>
<td>Total value,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$154,003</td>
</tr>
</tbody>
</table>
State of Texas Mine

Situation: The State of Texas Mine is in Montezuma Canyon, near the southeastern end of the Huachuca Mountains. It is about 30 miles from Bisbee, via State Highway 92 and the Montezuma Pass road. When visited in 1948, the property consisted of one patented and six unpatented claims, held by Miss Grace Sparkes.

History: Locations in this area were made by August Baron, of Tombstone, in 1889, and his State of Texas claim was surveyed for patent in 1898. A few years later Baron’s claim and thirty-two other claims in the area were acquired by the Mitchell Development Company, of Ishpeming, Michigan. As reported in the Copper Handbook, workings by 1904 consisted of three tunnels, a shaft about 250 feet deep, and a shallower shaft. According to Grebe, some copper ore was reported to have been found in the main shaft at a depth of 300 feet and in diamond-drill holes below the 350 level. The Mitchell Development Company liquidated in 1906, and the property remained essentially idle until World War II.

According to Miss Sparkes, production during 1943-47 totaled 1,791 tons, which was sent to the Shattuck Denn custom mill at Bisbee. This ore yielded essentially all of the output of recoverable zinc (330,000) credited to the Hartford district for the years 1943-46. Also, it contained from 1.0 to 6.65 per cent lead and 0.2 to 1.12 per cent copper, together with 2.75 to 11.0 ounces of silver and generally less than 0.1 ounce of gold per ton. It commonly ranged from 10 to 19.65 per cent in zinc content.

Geology: The State of Texas mine is on the north side of Montezuma Canyon, at an altitude of approximately 5,700 feet. From top to bottom this side of the canyon shows the following sequence of rocks: (1) Granite rock, classified as quartz monzonite by Weber, forming large mass of ridge; (2) marble, approximately 60 feet thick; (3) impure dark-gray limestone, approximately 40 feet; (4) porphyry sill, 5 to 20 feet; and (5) reddish-brown shade, sandstone, and quartzite, to bed of canyon.

The marble and limestone resemble portions of the Carboniferous Escabrosa and Naco formations, and the underlying shale-sandstone series is probably Cretaceous; low-angle and steep reverse faulting has thrust the older rocks over the younger rocks. The porphyry sill was intruded along a low-angle fault, and presumably the larger masses of quartz monzonite came in along zones of reverse and shear faulting. In places renewed fault movement occurred along the contacts; for example, a fault zone, dipping 80 degrees northward and locally marked by copper stain, separates the marble from the intrusive mass north of the mine. The marble and limestone south of this fault form a belt approximately 350 feet wide and several hundred feet long from east to west. Their beds in general dip 15 to 50 degrees northward, but in places they have been deformed by flexures and faults.
Workings and mineralization: The zinc-lead workings in the State of Texas mine are about 200 feet southeast of the old Mitchell vertical shaft. They consist of an adit with about 250 feet of drifts and an irregular stope about 80 feet in maximum length and breadth by 5 to 15 feet high.

The ore consists essentially of sphalerite and galena together with local pyrite and a little chalcopyrite. It occurs associated with garnet and other silicates, minor quantities of willemite (?), calcite, and quartz.

As seen in the workings, the ore replaced favorable portions of the impure limestone within the arch of a northward-plunging low anticline. The roof in the southern part of the stope shows a fault dipping 20 degrees southward immediately above the ore. Two fissure zones, about 25 feet apart, striking N. 80 degrees W., and almost vertical, are associated with the best-developed mineralization. Presumably the ore-bearing solutions were localized to a considerable extent along these fissures. The surface outcrop of the stronger zone of fissuring, marked particularly by dark limonitic alteration, extends east of the present workings.

North of the stope a short drift extends into unmineralized marble. During 1948 two inclined diamond-drill holes driven from this drift found high-grade sphalerite, together with some galena and chalcopyrite, at a depth of about 55 feet vertically below the floor of the stope. Not enough development work has been done to determine the attitude, thickness, and extent of this mineralization.

One of the drill holes encountered quartz monzonite at a vertical depth of 85 feet below the floor of the stope. Granitic rock also occurs in workings northeast of the stope and is there faulted against the limestone. Presumably these granitic bodies are sills, but their thickness, extent, and structural relations are not evident.

Panama or Manila Mine

The Panama or Manila mine is on the northern margin of the Huachuca Mountains, ½ mile south of the Canelo-Fort Huachuca road.

Figures of the total production from this property are not available. It is credited with shipments of 132 tons of ore, averaging 14 to 31 per cent lead and about 1.5 ounces of silver per ton, in 1925; one car of lead ore in 1926; and one car of oxidized lead ore in 1928. In 1926, Hauchuca Queen Mining Company built on the property a flotation plant, reported to have been of 85 tons daily capacity. The main vertical shaft was reported in 1925 to be 300 feet deep.

According to Alexis,

Water was encountered 125 feet below the surface in the main shaft, and pumping was required. The pumping was stopped by a court injunction on June 9, 1928, because the spring on the Pyeatt Ranch ran dry allegedly as the result of the pumping operations.
Sometime after the court injunction had been issued, a resurvey found that the mine was 200 yards within the Military Reservation. The operators were then obliged to move their equipment from the property and cease all operations.

The major structure in the Panama mine area is the Crest Line fault, which has thrust Paleozoic limestones over Lower Cretaceous strata, mostly red shales and sandstone. The fault surface dips to the north less than 10 degrees. The overthrust plate of Paleozoic limestone has largely been removed by erosion, so that the overthrust block is less than 100 feet thick.

The mineralization is on a steeply dipping northeast fissure which cuts the Paleozoic limestones and the Cretaceous strata below the thrust-fault surface. Specimens of ore collected from the adit level consisted of cerussite in a quartz and calcite gangue with a little malachite. Except for the adit level, the mine was not accessible for study.

**OTHER ZINC AND LEAD MINES**

*Armistice mine:* The Armistice mine is credited with shipments of several cars of silver-lead ore during 1940-41; 73 tons in 1942; 91 tons of lead ore in 1943; 50 tons of lead-silver ore in 1944; 156 tons of lead ore in 1948; and a few tons in 1949.

*Cave mine:* The Cave mine produced some zinc-lead ore in 1946. In 1947 it was operated by Cave Mountain Mines Corporation and produced 388 tons containing 73,716 pounds of zinc, 50,281 pounds of lead, 3,938 pounds of copper, and 285 ounces of silver.

*James mine:* Production of lead ore from the James tungsten mine is reported as 25 tons in 1947 and a small amount in 1945.

The *Anne Marie* and *Borderland Metals* properties produced small quantities of lead ore during 1949.

**REFERENCES, HUACHUCA MOUNTAINS**

3. For years prior to 1930, partly from unpublished notes of J. B. Tenney.
CHAPTER V.—ORO BLANCO OR RUBY DISTRICT

INTRODUCTION

The Oro Blanco district is in the eastern portion of the Oro Blanco Mountains of southwestern Santa Cruz County. Its principal settlement, Ruby, in the eastern part of the district, is 32 miles by road from Nogales and about 34 miles from Amado, a station on the Southern Pacific railway.

The portion of the Oro Blanco Mountains in the vicinity of Ruby comprises a series of ridges and southward-trending canyons ranging in altitude from 3,600 to 5,400 feet. Topography of this area is shown on the Ruby and Oro Blanco quadrangle sheets, published by the U.S. Geological Survey on a scale of 1:62,500 and a contour interval of 50 feet.

HISTORY

Gold deposits in the Oro Blanco district probably were worked by the early Spaniards. American locations were made in 1873 on the Oro Blanco vein. The prominent quartz outcrop now known as the Montana vein was located in the early seventies. Other locations followed soon afterward, and rich gold ore was ground in arrastras. The Ostrich mill, equipped with a roasting furnace to treat refractory sulphide ores, was built during the early eighties and operated by the Orion Company on ore from the Montana and Warsaw mines. This company obtained the Montana property and by 1884 had been reorganized as the Montana Company, controlled by Tombstone Mill and Mining Company.

The Warsaw mill was built in 1882 and operated as a custom plant. In 1884 Esperanza Mines Company built a mill to treat ore from the Blain ledge.

From 1887 to 1893, most of the mines were inactive.

During 1894-96 mills operated at the Austerlitz, Yellow Jacket, Old Glory, Oro, and Golden Eagle mines.

At the Montana mine a 10-stamp mill, utilizing concentration and pan amalgamation methods to treat oxidized lead-gold-silver ores, was built in 1891 but abandoned in 1893. The Montana claims were patented in 1907 by L. Zeckendorf.

In 1903 amalgamation and cyanide mills were built to treat gold and silver ores from properties in the district.

After 1904 little work was done until 1912 when the Austerlitz and Oro mines were reopened. A concentrator was built at the Austerlitz and operated for more than one year.

In 1916 Goldfield Consolidated Mines Exploration Company obtained an option on the Montana property, completed a mill using flotation, and developed the mine to about the 250 level. It ceased operations in 1918, partly because of labor shortages, and gave up its option.

In 1926 Eagle-Picher Lead Company, as Montana Mines Operations, took an option on the Montana property. A mill of 250 tons

References are listed numerically at end of chapter.
daily capacity, equipped to use differential flotation methods,\(^3\) was completed in 1928. It was provided with an adequate water supply by means of a pipe line 15 miles long from Santa Cruz River. The mill was run intermittently until 1930. Subsequently its capacity was increased, and extensive production was maintained from late 1934 until May, 1940, by Eagle-Picher Mining and Smelting Company. The Montana Mine ranked as the largest producer of lead and zinc in Arizona for 1935 to 1939, inclusive, and third in output of silver for 1938.

During recent years, Hugo Miller, of Nogales, has shipped from the Montana property lead-silver ore to the smelter at El Paso, Texas, and lead-zinc ore to the Eagle-Picher mill at Sahuarita, Arizona. Also, zinc-lead ore has been produced from the Choctaw and Lucky Shot mines; zinc-copper and copper ore from the Horn Gold claim; and gold and silver ore from several properties, as reported in the U.S. Minerals Yearbooks.

**PRODUCTION, ORO BLANCO DISTRICT\(^1\)**

<table>
<thead>
<tr>
<th></th>
<th>Silver, 1909-49</th>
<th>4,009,527 oz., valued at $2,700,179</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold, 1873-1949</td>
<td>98,142 oz.,</td>
<td>2,623,069</td>
</tr>
<tr>
<td>Lead, 1909-49</td>
<td>54,562,801 lb.,</td>
<td>2,688,818</td>
</tr>
<tr>
<td>Zinc, 1917-49</td>
<td>38,256,989 lb.,</td>
<td>2,061,017</td>
</tr>
<tr>
<td>Copper, 1909-49</td>
<td>3,152,630 lb.,</td>
<td>334,942</td>
</tr>
</tbody>
</table>

Total value through 1949..........................................................$10,498,025

The output of lead and zinc by periods was as follows:

<table>
<thead>
<tr>
<th></th>
<th>Lead Pounds</th>
<th>Lead Value</th>
<th>Zinc Pounds</th>
<th>Zinc Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1909-16</td>
<td>20,868</td>
<td>$857</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1917-18</td>
<td>1,378,198</td>
<td>106,258</td>
<td>1,171,641</td>
<td>$110,165</td>
</tr>
<tr>
<td>1919-27</td>
<td>12,000</td>
<td>1,044</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1928-30</td>
<td>6,371,489</td>
<td>369,079</td>
<td>4,788,361</td>
<td>234,570</td>
</tr>
<tr>
<td>1932-33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1934-40</td>
<td>46,386,146</td>
<td>2,160,909</td>
<td>32,122,187</td>
<td>1,644,293</td>
</tr>
<tr>
<td>1941-49</td>
<td>394,100</td>
<td>50,671</td>
<td>174,800</td>
<td>21,989</td>
</tr>
</tbody>
</table>

**MINERALOGY OF THE ORES**

According to Warren and Loofbourow,\(^3\)

Galena and blende are by far the most important of the sulphides, and the paragenesis of most of the other minerals can be related to them. The galena is the younger of the two.

Pyrite occurs chiefly in the form of small cubes in kaolinitic material. It occurs less commonly in a shattered condition, with the fractures healed by tetrahedrite and more rarely by galena.

Chalcopyrite is prominent and, although it does occur in minute specks in the blende, it is most conspicuous along the borders of either the galena and tetrahedrite or the blende and tetrahedrite. It also occurs as specks in the tetrahedrite.

The tetrahedrite is younger than the blende, and at least a part is older than the galena in which it occurs as specks. These spots are largely responsible for the silver content of the galena.

The gold present shows no direct relationship to the amount of zinc, lead, or iron present, but it does show a marked relationship to the silver and copper.

Pyrite and blende carry none and chalcoprite little, if any, of the gold and silver in the ore.
ARIZONA ZINC AND LEAD DEPOSITS

It is worthy of note that the pure blende carried 0.41 and 0.52 per cent of cadmium in the two samples which were analyzed.

The tetrahedrite contains as much as 4 per cent of the silver and one-half ounce of gold per ton of mineral, and in the form of minute specks is responsible for at least a part of the silver found in the supposedly pure galena, which in fact carries only about 0.033 per cent silver.

Head\(^a\) found none of the tetrahedrite specks to be larger than 300 mesh.

According to Fowler\(^2\), alteration products of these minerals occur very sparingly in the upper levels. The natural water level is a few feet below the 525 level, and the volume of water is small.

MONTANA MINE

PRODUCTION

Most of the lead and zinc produced in the Oro Blanco district has come from the Montana property. No records of the early output, which was chiefly gold and silver, are available.

A total of 773,197 tons of ore from the Montana property was milled during 1928-40, according to George M. Fowler\(^2\) and the U.S. Minerals Yearbooks.

As given by Fowler\(^2\), the record for 1934-37 was as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Tons</th>
<th>Ounces per ton</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Milled</td>
<td>Gold</td>
<td>Silver</td>
</tr>
<tr>
<td>1934</td>
<td>36,963</td>
<td>0.075</td>
<td>6.14</td>
</tr>
<tr>
<td>1935</td>
<td>129,374</td>
<td>0.070</td>
<td>5.77</td>
</tr>
<tr>
<td>1936</td>
<td>141,768</td>
<td>0.060</td>
<td>5.21</td>
</tr>
<tr>
<td>1937</td>
<td>143,004</td>
<td>0.053</td>
<td>5.06</td>
</tr>
</tbody>
</table>

GEOLOGY\(^2\)

By George M. Fowler

The rocks in and around the Montana mine consist largely of andesite, quartz monzonite, conglomerate, diorite of various types and several ages, and rhyolite and allied rocks and tuffs (Fig. 9). Small patches of shale occur in a few scattered areas. All the formations earlier than the Blue Ribbon diorite, described later, have been cut by intrusive stocks and dikes.

The andesite and quartz monzonite are thought to be the oldest formations in the district, but their age relation is uncertain, as they are some distance from the mine workings and have been little studied. The andesite covers a large area in and east of California Gulch, a few hundred yards east of the Montana vein. Quartz monzonite was found in a diamond drill hole under the Montana mine workings at a depth of about 1,000 to 2,044 feet, the bottom of the hole. The upper part of this formation is leached and the crystals and groundmass show marked fracturing. Surface exposures of it are absent in the vicinity of Ruby.

It was relatively easy to establish the age relationship of the other rocks, as many thousand feet of mine workings and many diamond drill holes thoroughly explore them. The rocks in sequence are:

1. Oro Blanco conglomerate—named from the mining district
in which the property is located. It is tentatively regarded as of Mesozoic age.

2. Ruby diorite—named from the mine settlement.

3. Sidewinder diorite porphyry—named by the miners because numerous dikes of it trend along and through the veins.

4. Blue Ribbon diorite—named from the characteristic bluish coloring of its outcrop.

5. Rhyrolite and other volcanics which occur as flows and tuffs.

The Oro Blanco conglomerate, the host rock for the ores at the Montana mine, covers a large area in the western part of Santa Cruz County and is probably part of a similar formation that is widespread in south-central Arizona, from west of the Baboquivari Mountains to the Santa Rita Mountains east of the Santa Cruz River.

The conglomerate is characterized by the angularity and the coarseness of its constituent fragments. It seems difficult to classify this rock, as it combines characteristics of a conglomerate and a breccia. The fragments range between an inch and 12
inches in diameter. Small gravel is present only in sufficient quantity to fill the interstices. The color is reddish and grayish, with some dark-hued, greenish fragments that give the mass a variegated appearance in some places.

The late Fred E. Gregory, former chemist and geologist at the Montana mine, studied the glomeratic material, and his notes show that the fragments are with one exception of igneous origin, derived in part from surface and partly from deeper-seated types. Quartzite represents the exception noted. The cementing material is mostly silica and exceptionally calcium carbonate.

The relative abrasion of the fragments indicates that the plutonic rocks have been transported a shorter distance and the effusive and metamorphic rocks a greater distance.

Ruby diorite, the footwall of the Montana vein in parts of the workings, covers a large area south of the Montana mine. It is darker, finer grained, and denser than the younger diorite. Fragments of conglomerate are included in this diorite, and dikes of Sidewinder and Blue Ribbon formations cut it. A crosscut on the 500 level, southeast of the Montana shaft, penetrates the Ruby diorite and a large inclusion of the conglomerate.

The Sidewinder diorite porphyry, which is younger than the veins, is widely exposed on the surface and underground. It occurs as dikes parallel to the Montana vein and as large, compact masses on all sides of the mine. The general strike of the dikes is easterly and the dip about 40 degrees to the north, which is about the same dip and strike as the Montana vein. The dikes range in thickness from a few feet to more than 100 feet. Some dikes forced their way into fissures on one or both sides of the numerous splits of the vein system and between segments of the veins, which further complicated the structural pattern of these ore deposits.

On the 100 level south of the main shaft a little ore was mined from a fissure in crests of a Sidewinder dike. The material included angular and rounded pieces of ore and barren fragments of conglomerate and diorite porphyry that had been pushed ahead of the dike. In another place a large segment of the Rough and Ready vein was pushed aside laterally by a dike. The segment then broke into several large pieces and Sidewinder dike material filled the intervening spaces. This ore body was more than 100 feet in height.

The Blue Ribbon diorite is the youngest igneous formation in the mine workings. It is well exposed in front of the guest house at the mine. It is fine grained and weathers rapidly to a soft bluish color. Dikes are present in the mine workings and over a large area south of the mine. The dikes in the mine are designated on the map as the Montana, Rough and Ready, and Philadelphia (Fig. 9). The first two, about 30 feet wide, strike nearly north and cut the veins at right angles.

The Oro Blanco conglomerate rests on a weathered quartz monzonite surface under the mine workings, a relationship which may be widespread.
Structural deformation and the ore deposits are so closely related that it seems best to discuss them together. It is apparent from the surface geology that deformation was regional in character and of greatest intensity in the vicinity of Ruby. Oro Blanco conglomerate occupied depressions in the region to a depth of many hundred feet. The conglomerate and the younger formations were intruded successively by the Ruby diorite, Sidewinder diorite porphyry, and Blue Ribbon diorite.

The conglomerate-Ruby diorite contact presents a jagged surface, as numerous projections of the diorite extend a few feet into the conglomerate. In the mine a shear zone, known as the Montana vein, trends east-west along this contact. Its width ranges from mere stringers to more than 40 feet. All the ore bodies are in shear zones along this contact or in the conglomerate. Some shear zones branch with barren country rock between branches. Wide ore bodies in the conglomerate change to small stringers in the diorite. It seems probable that the diorite was resistant to deformation, whereas the conglomerate shattered intensely and made ideal ore reservoirs.

The shear zones dip from 40 degrees N. to almost vertical. In plan they are arranged in echelon with offsets ahead and to the right. The most important veins are the Montana and the Rough and Ready (Figs. 9, 10, and 11).

The Montana vein can be traced on the surface for about 3,000 feet, in part as bold outcrops of quartz several hundred feet long and 50 feet wide, as exposed a few hundred feet south of the Montana shaft and around the Jenkins shaft.

The outcrops of the Rough and Ready vein are numerous small, barren fissures, some of which contain quartz stringers. The vein was practically barren to a depth of about 300 feet.

The Ore shoots in the Montana and Rough and Ready veins pitch about 45 degrees westward (Fig. 10). It seems probable that the center segment of the Montana vein dropped on the Montana dike, as the stopes on opposite sides of the dike have a vertical difference of more than 100 feet.

On the surface, in the mine workings, and in drill holes are many minor veins contiguous to the Montana-Rough and Ready vein system. Some of these on Company-owned property have been prospected with negative results.

The earliest mineralization at the Montana mine was barren, milky-colored quartz which was deposited in the shear zones and replaced some of the country rock. It ranges in thickness from minute bands to veins many feet wide. Subsequent deformation shattered the brittle quartz and country rock and made excellent reservoirs for the ore-bearing solutions that replaced most of the quartz and country rock to form some of the ore bodies. Zones of intense deformation and little movement, such as the loci of
Figure 10.—Montana mine, longitudinal projection, looking north. Shaded areas indicate stopes. (By George M. Fowler, Ariz. Bureau of Mines Bull. 145.)
Figure 11.—Montana mine, vertical section across veins, looking west. Line of section approximately 130 feet east of Rough and Ready dike. (By George M. Fowler, Ariz. Bureau of Mines Bull. 145.)
torsional stresses, became particularly favorable ore reservoirs. Some of the zones show a fracture pattern with the major ore stringers trending with the vein and minor stringers crossing it at oblique angles.

Post-ore faulting had only a minor influence in the ore bodies. Large faults follow the footwalls, and in some cases the hanging walls, of the vein system. A few faults parallel the veins with little displacement. Dikes of Blue Ribbon age were displaced a few feet.

REFERENCES, ORO BLANCO DISTRICT


CHAPTER VI.—EMPIRE DISTRICT

Compiled by Eldred D. Wilson

INTRODUCTION

The following description of the Empire district has been compiled largely from the work of others. In 1909, Schrader briefly studied the district. Further geologic work has been carried on in the area by members of the Geology department of the University of Arizona and by students under their direction. Acknowledgments are due Professor F. W. Galbraith for assistance in preparing this chapter.

PHYSICAL FEATURES

The Empire Mountains extend between Davidson Canyon and Cienega Creek for about 8 miles northeastward from the Santa Rita Mountains and attain a maximum altitude of about 5,500 feet. They are characterized by a bold western escarpment facing Davidson Canyon, and a broad eastern pediment.

The principal habitations are Andrada ranch on the northwest and Hilton goat ranch in the south-central portion. State Highway 83 follows Davidson Canyon. U.S. Highway 80 and the Southern Pacific railway are within 4 miles of the

1 References are listed numerically at end of chapter.
northern edge of the area. Branch roads from these routes enter the Empire Mountains.

Topography of the range is shown on the Patagonia quadrangle topographic sheet, published by the U.S. Geological Survey.

ROCKS

The stratigraphic sequence in the Empire Mountains has been interpreted as follows:

<table>
<thead>
<tr>
<th>Age, formation, and character</th>
<th>Thickness in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Cretaceous</strong></td>
<td></td>
</tr>
<tr>
<td>Conglomerate, sandstone, shale and arkose, interbedded with volcanic flows. Unconformity</td>
<td>5,000+</td>
</tr>
<tr>
<td><strong>Permian</strong></td>
<td></td>
</tr>
<tr>
<td>Snyder Hill formation: Thick-bedded limestone with several quartzite members</td>
<td>1,250-2,250</td>
</tr>
<tr>
<td>Andrada formation: Shale, marl, limestone and gypsum</td>
<td>300-1,500</td>
</tr>
<tr>
<td><strong>Pennsylvanian</strong></td>
<td></td>
</tr>
<tr>
<td>Naco formation: Medium to thin-bedded limestone, interstratified with thin shale</td>
<td>1,200</td>
</tr>
<tr>
<td><strong>Mississippian</strong></td>
<td></td>
</tr>
<tr>
<td>Escabrosa limestone, relatively thick-bedded and pure</td>
<td>200-600</td>
</tr>
<tr>
<td><strong>Devonian</strong></td>
<td></td>
</tr>
<tr>
<td>Martin limestone, somewhat sandy</td>
<td>100-300</td>
</tr>
<tr>
<td><strong>Cambrian</strong></td>
<td></td>
</tr>
<tr>
<td>Abrigo limestone, thin-bedded and cherty; base not exposed</td>
<td>750</td>
</tr>
</tbody>
</table>

The Cretaceous and older rocks were intruded by quartz monzonite and granodiorite which, in the west-central portion of the range, crops out over an area some 3 miles long from north to south by 1 to 2 miles wide and is termed the Sycamore stock. Its age tentatively may be considered as Laramide (late Cretaceous-early Tertiary).

Dikes of rhyolite porphyry, aplite, syenite, andesite, and basalt intrude various formations of the sedimentary series, and some of them cut the Sycamore stock.

STRUCTURE

After deposition of the Cretaceous beds, this region underwent intense deformation.

In general the beds lie in a broad dome surrounding the Sycamore stock. Superimposed upon this dome were numerous southeastward-pitching folds. Bedding-plane faults are common within them.

As summarized by Galbraith, "The dominant structural feature of the Empire Mountains is a low-angle fault which dips to the southeast. On this fault the entire Paleozoic mass has moved over the Upper Cretaceous sedimentaries.

"Large tear faults accompanied, and smaller normal faults followed, the overthrusting. Intrusion was later than the overthrusting and possibly concurrent with the normal faulting."

Minor thrust faults are present in the main overthrust mass.
The tear faults strike northwestward, dip steeply, and have effected important horizontal displacements. One of the largest, the Andrada fault, lies immediately north of the Total Wreck mine. As shown by Alberding, the beds on northeast side of this fault appear to have been moved 8,000 feet northwestward relative to those on the southwest side.

Steeply dipping normal faults strike northwest, north, and east-west.

Low-angle faults of reverse character strike northeastward.

ORE DEPOSITS

Types

The ore deposits of the Empire district are of replacement and contact types.

Replacements: The replacement deposits occur principally in Snyder Hill limestone and subordinately in Andrada and Cretaceous formations. For the most part they are localized within overthrust blocks, in the near vicinity of northwesterly tear faults. Further control is suggested by their association with steeply dipping east-west and northeasterly fissures.

Representative of the replacement deposits are the Total Wreck mine which has been the largest producer of silver, lead, and wulfenite ore in the district; mines of the Hilton area, which have yielded lead, silver, copper, zinc, and gold; and the Montana or Black Diamond copper mine.

The Total Wreck and Hilton mine areas are several thousand feet away from outcrops of the Sycamore quartz monzonite stock, but the Montana is relatively near its northwestern margin. Dikes and small bodies of porphyry occur more or less closely associated with the Hilton deposits.

Contact deposits: Of the contact type are the California or Mann copper deposit and the disseminated scheelite deposits on Hilton's ranch.

PRODUCTION

The metal production of the Empire district during 1915-48 has been as follows:¹²

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>6,630,734 pounds, valued at $471,528</td>
<td></td>
</tr>
<tr>
<td>Silver</td>
<td>103,620 ounces, 75,660</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>375,914 pounds, 35,580</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>120,485 pounds, 19,132</td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td>617 ounces, 12,470</td>
<td></td>
</tr>
</tbody>
</table>

$614,370

In addition, the value of lead and silver output prior to 1915 is estimated as $500,000 or more, and a little molybdenum was produced from wulfenite concentrates during 1917-18.

The principal lead and silver production came from the Total Wreck mine during 1880-84, 1907-10, and 1915-27. The zinc, produced mainly during 1942-43 and to a smaller extent during 1918 and 1925, was largely from carbonate ores of the Hilton area.

No production was reported from the district in 1949.
TOTAL WRECK MINE

Situation: The Total Wreck mine is in the northeastern part of the Empire Mountains, at an altitude of 4,600 feet. It is accessible by 9 miles of road from Pantano, a station on the Southern Pacific railroad.

History and production: The deposit was discovered in 1879 and actively worked during the early eighties. Empire Mining and Development Company acquired the property, built a 20-stamp mill, and operated actively during 1881-82 on ore of high silver content. The cost of mining and milling is reported to have been $8 per ton. As reported by Hamilton, operations during five months of this time yielded $450,000 from 7,500 tons.

As described in the Tucson Weekly Star, the camp had three general stores, four saloons, and several Chinese laundries. The mine and mill were closed by the end of 1884 and subsequently sold for taxes to Vail and Gates.

Considerable ore was reported to have been shipped from the mine during 1907-10.

In 1917-18 wulfenite concentrates were produced at the Total Wreck. Some of these concentrates were shipped to Molybdenum Products Company, at Tucson. As described by Hess,

During the first part of 1917 this firm treated the wulfenite in a reverberatory furnace with soda ash and made a sodium-molybdate slag and metallic lead. Later a blast furnace was put up, and the same products were made in it. For a time it was difficult to sell either the concentrates or the sodium molybdate, and ferro-molybdenum was made in small electric furnaces manufactured at the plant.

Later the sodium-molybdate slag was sold to the Atlantic Metal and Alloy Company, at Boonton, N. J., which made ferro-molybdenum from it.

The mine produced oxidized silver-lead ore intermittently from 1922 to 1928. In 1926 more than 1,000 tons of old tailings containing about 6 per cent lead, 1 per cent copper, and 7 ounces of silver per ton were shipped from the mill dump. Similar shipments were made in 1927.

The total production from the Total Wreck mine is not known. Estimates of the value of silver and lead output range from $500,000 to $1,000,000.

Geology: The following description is abstracted from Alberding and Schrader.

The Total Wreck mine is within the Permian Snyder Hill formation, which consists of thin-bedded gray and black limestone and dolomite together with thin beds of quartzite. Basal Cretaceous conglomerate overlies the Snyder Hill on the southeast. Small dikes of diorite intrude these rocks.

In general the beds strike N. 60 degrees E. and dip 35 degrees SE. Immediately north of the mine is the Andrada fault, whose irregular outcrop averages northwest in strike and 85 degrees NE. in dip. As previously mentioned, it may be regarded as a tear break of large horizontal displacement. South of this fault the sedimentary succession has been sliced in a complicated
manner by low-angle faults of southeastward dip; also, according to Galbraith,\(^6\) it is broken by faults which parallel the Andrade fault. Hence the rocks in the vicinity of the mine are affected by faults and fissures of east-west and northeasterly trend and somewhat folded. Vein No. 1 or North fissure and Vein No. 2 or South fissure are 90 feet apart, strike east-west, and dip 85 degrees N. Intersecting them with downthrown side on the southeast is the Main vein or fault, which strikes N. 30 degrees E., dips 85 degrees southeastward, and disappears under low-angle faults on the southwest.

**Ore deposits:** According to Schrader\(^1\) the ore deposits occur within zones of the No. 1 and No. 2 fissures and Main fault and as replacements extending from them along bedding planes of the limestone. The “veins” are 6 to 8 feet wide. The replacements extend outward for a few feet to about 100 feet, both above and beneath beds of quartzite, north from the No. 1 and No. 2 veins and on both sides of the Main vein.

The deposits extend from the surface to the bottom level of the mine, and their lower limits are not known to have been reached.

Practically all of the commercial ore mined was between the surface and the 350 level.

The ore occurs within altered, more or less crushed, limestone with calcite and cellular quartz. Associated with the mineralization in places, as on the 450 level, is breccia 40 to 50 feet wide, together with some light-colored clay material.

The ore is essentially all oxidized. Its silver content was high in workings near the surface but decreased markedly with depth. Ore minerals are principally cerargyrite, cerussite, wulfenite, malachite, azurite, chrysocolla, a little chalcopyrite, and perhaps lead oxides. Associated minerals include hematite, limonite, vanadinite, jarosite, siderite, and manganese oxides. The ore was richest in silver in the upper workings, but contained less silver and more copper with greater depth.

The mine is developed to a depth of approximately 500 feet by shafts, adits, drifts, inclines, and stopes, which by 1910 aggregated about 5,000 feet of work. These workings are sketched in Schrader’s report,\(^1\) and a plan of them is shown in Figure 12.

No water was encountered in the mine.

**Hilton Area Mines**

**Situation:** The Hilton or Lead Mountain area is 3 miles southwest of the Total Wreck mine and 2 miles east of Davidson Canyon, from which it is accessible by Hilton’s ranch road.

**History:** According to Alexis,\(^7\) claims were located in this area during the late seventies and early eighties. At about the beginning of the present century they were worked for several years and produced ore valued at approximately $20,000. In 1902 Verde Queen Mining Company bought the claims but shipped very little ore. Subsequently the property was acquired by M. P. Hilton. During 1927 Calumet and Arizona Mining Company did consid-
erable development work in the Prince mine and shipped from it ore valued at about $25,000. E. P. Hilton, the present owner, has continued intermittent shipments of high-grade oxidized lead and zinc ore.

Probably most of the production credited to the Empire district during 1928-48, which included 1,655,866 pounds of lead, 301,300 pounds of zinc, 19,173 ounces of silver, 53,602 pounds of copper, and 186 ounces of gold, in all valued at $161,011, has come from this area.

Geology and ore deposits: The following description is abstracted from Alexis, Mayuga, and Feiss.

The principal mines are in the Snyder Hill formation, and smaller deposits have been found in limestone members of the Andrada formation. The beds strike eastward and dip at an average of 40 degrees southward. They are cut by several northwestward-
trending faults which may represent tear breaks, and are intruded by dikes of northeasterly trend. In addition, many small north-south normal faults, northeasterly fissures, and bedding-plane faults are present. The exposed rocks are interpreted as part of an overthrust mass.

Ore occurs as pipe-like bodies and irregular replacements. Apparently the ore solutions came in along northeasterly fissures and were localized by northerly and northwesterly breaks.

The ore minerals include cerussite, anglesite, smithsonite, and malachite, together with subordinate amounts of aurichalcite, galena, plumbojarosite, azurite, wulfenite, and jarosite. Limonite, hematite, calcite, and quartz occur associated with the ore.

Most of the lead and zinc production has come from carbonate ores of the Chief, Prince, Gopher, and 49 mines.

A faulted rhyolite-porphyry dike, dipping about 60 degrees northwestward, extends northeasterly through the Chief and 49 claims. Diorite forms a sill in the Prince, and a northwest-dipping dike in the 49 mine. Ore occurs below the diorite in the Prince, Chief, and 49.

In the 49 mine the ore forms an elongated replacement body along the intersection of beds with the southeast contact of a rhyolite-porphyry dike, and pipe-like bodies on the northwest contact. The principal workings are on the 80 level.

In the Chief and Gopher mines the ore occurs as chimneys along intersections of northeast and northwesterly fissures. As of 1939, the Chief had been developed to the 200 level, and the Gopher to the 300 level. Water stood at about 30 feet below the 300 level.

According to Feiss, ore in the Prince mine occurred mainly as small pockets associated with fissures in the limestone. He noted strong oxidation on the 750 or deepest level, presumably 250 feet below the present water table.

REFERENCES, EMPIRE DISTRICT

CHAPTER VII.—BUNKER HILL DISTRICT

By Truman H. Kuhn1

PHYSICAL FEATURES

The Bunker Hill district of eastern Pinal County includes an area approximately 10 miles long by 4 miles wide in the northwestern portion of the Galiuro Mountains. Copper Creek, the only settlement, is 11 miles by road east of Mammoth and 32 miles southeast of the railway at Winkelman.

The topography of this portion of the Galiuro Mountains is shown on the Klondyke, Galiuro, and Winkelman quadrangle sheets, issued by the U.S. Geological Survey. Rising steeply from an altitude of 3,500 to 5,650 feet, the bold southwestern front of the range has been deeply dissected by westward-flowing tributaries of the San Pedro River. The canyon of Copper Creek, an intermittent stream, forms an irregular, rugged basin which includes the central or most productive part of the district, which is generally referred to as the Copper Creek area.

Water for the Blue Bird mine and mill was supplied by a spring in the lava near the head of Childs Canyon. For other milling operations in the district, it was obtained partly from wells tapping the underground flow of Copper Creek and partly from the Globe and Copper Prince shafts. Various tunnels have furnished water for domestic use.

HISTORY

Rich silver-lead ore was mined from the Blue Bird vein as early as 1863, and the Bunker Hill mining district was recorded in 1883. Comparatively little work, however, was done in the area until after 1902.

In 1903, Copper Creek Mining Company acquired claims along Copper Creek. During 1907-09, Calumet and Arizona Mining Company prospected the Copper Prince, Globe, Copper Giant, Superior, and other pipe deposits.

The construction of a wagon road from Mammoth to Copper Creek in 1908, followed by completion of the Arizona Eastern rail-

1 References are listed numerically at end of chapter.
way from Phoenix to Winkelman in 1911, encouraged development in the district.

After 1907, Minnesota-Arizona Mining Company prospected numerous deposits in the area formerly held by Copper Creek Mining Company, built a mill, and installed a steam-electric power plant.

In 1910, Copper State Metals Mining Company, a reorganization of Minnesota-Arizona Copper Company, acquired the Blue Bird mine, then known as the Twin-S, and renamed it the Cumberland. George Young obtained the mine in 1914 and worked it in a small way. During 1918-30 the property was operated successively by Blue Bird Silver Mining Company, Twin-S Mining Company, and Field Mining Corporation. Intermittent production continued, and during 1939-40 Blue Bird Mining Company treated the ore in a mill of 25 tons daily capacity. In 1947 Bluebird Mines, Inc. reopened the mine, treated 500 tons of lead-copper ore in its mill of 50 tons daily capacity, and shipped 98 tons of lead ore. For 1948, a production of only 7 tons of ore was reported from the Blue Bird.

The Bunker Hill mine, near Sombrero Butte, south of the Copper Creek area, was acquired in 1917 by Bunker Hill Copper Company and worked for lead-copper ore during 1918. Intermittent production continued from this mine during 1923-29, 1934, and 1936.

In 1933 Arizona Molybdenum Corporation purchased the Childs-Aldwinkle property and produced molybdenum and copper ore until late 1938, after which lessees worked it for about a year.

In 1948, approximately 228 tons of lead ore from the Red Bird mine was milled.

During 1949-50, the district was largely inactive.

**PRODUCTION**

<table>
<thead>
<tr>
<th>Metal</th>
<th>1933-38</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molybdenum</td>
<td>4,173,632 pounds</td>
<td>$2,951,923</td>
</tr>
<tr>
<td>Copper</td>
<td>9,908,326 pounds</td>
<td>1,187,994</td>
</tr>
<tr>
<td>Lead</td>
<td>3,180,293 pounds</td>
<td>219,145</td>
</tr>
<tr>
<td>Silver</td>
<td>241,000 ounces</td>
<td>155,500</td>
</tr>
<tr>
<td>Gold</td>
<td>1,273 ounces</td>
<td>39,191</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$4,553,753</strong></td>
</tr>
</tbody>
</table>

**ROCKS**

*General statement:* The oldest rocks exposed in the Copper Creek area (Figs. 13 and 14) consist of limestone, quartzite, conglomerate, shale, and sandstone, interbedded with a complex series of andesite, rhyolite, and dacite tuffs and flows, and intruded by sills and dikes of andesite and dacite. All these rocks are probably of Cretaceous age. They are overlain by an extensive series of basalt flows, presumably of late Cretaceous or early Tertiary age, which cap much of the Galiuro Mountains. A medium-grained rock, predominantly granodiorite, intrudes the Cretaceous (?) series. Gila conglomerate, Pliocene in age, is faulted against the Cretaceous (?) rocks near the mountain front.
Figure 13.—Geologic map of part of Copper Creek area. (From Truman H. Kuhn. 1940.)
Earlier sedimentary beds: The earlier sedimentary rocks consist of quartzite, limestone, shale, conglomerate, and sandstone, which crop out as a relatively narrow band in the northwestern and southeastern portions of the area mapped on Figure 13. The main mass of quartzite in the southeastern portion is massive and white, but thin beds of banded blue-gray to white quartzite commonly occur interbedded with limestone and shale. The limestone, approximately 300 feet thick north and northeast of the Blue Bird mine, is indistinctly bedded, sandy, and white, buff, brown, or almost black in color. Conformably overlying the limestone are thin beds of red, buff, or green silicified shale. A persistent flat-lying bed of conglomerate about 50 feet thick overlies shale near the head of Limestone Canyon. Overlying the conglomerate is a thin bed of medium-grained yellowish-brown sandstone.

In places, andesite tuff overlies as well as underlies the sedimentary rocks. This relation obtains also in the Deer Creek area, 18 miles north of Copper Creek, where beds of known Upper Cretaceous age occur interbedded with andesitic rocks.

On the basis of their lithology, the sedimentary beds mapped on Figure 13 are regarded as Cretaceous. Furthermore, fossils collected from the limestone members were considered by Dr. A. A. Stoyanow, of the University of Arizona, as more suggestive of Mesozoic than Paleozoic forms.

Andesite tuff and andesite: Most of the western portion of the Copper Creek area is floored by a complex series of andesite tuff, interbedded with rhyolite and dacite tuffs, intruded by sills of andesite and dacite, and overlain by an andesite flow (Figs. 13 and 14).

The tuff consists of a greenish-gray, brown, buff, or red aggregate of quartzite and shale fragments up to a foot in diameter in a matrix of andesite. Dacite and rhyolite occur with it.

Granodiorite: A rock mass ranging from monzonite to diorite, but predominantly granodiorite, intrudes the Cretaceous (?) rocks and occupies much of the eastern portion of the area.

STRUCTURE

Sequence of events: The earliest record of deformation in the area is sharp folding of the Cretaceous (?) rocks, but the details of the folds have not been determined.

Faulting of the andesite tuff controlled, in part at least, the intrusion of the granodiorite. The stresses either continued or were renewed after solidification of this intrusive. Breccia pipes were formed, and ore minerals were deposited. Post-ore movement occurred along some of the faults.

Faulting: Comparatively few faults of large displacement are apparent in the district. Most of the adjustment has been by relatively small movement on a large number of breaks, as illustrated on Figure 13. Striations on the fault surfaces indicate that the latest movement was largely horizontal.
Figure 14.—Cross sections along lines A-B and C-D of Figure 13. Letter symbols: b, basalt; Kf, andesite flow; Kss, Cretaceous conglomerate, sandstone, quartzite, shale; Kls, Cretaceous limestone; Kt, andesite tuff; d, andesite, dacite, rhyolite dikes; grd, granodiorite; br, breccia pipes. (From Truman H. Kuhn, 1940.)
Four general directions of faulting, E.-W., N. 60 degrees E., N. 70 degrees W., and N. 10 degrees W. have been determined. In addition, one fault marked by considerable breccia strikes N. to 60 degrees W., and the fault contact between the Gila conglomerate and the older rocks near the southwestern corner of Figure 13 strikes approximately N. 25 degrees W.

Faults of the E.-W. system, striking from N. 85 degrees W. to S. 85 degrees W. and dipping from 75 degrees S. to 75 degrees N., are especially prominent in the southern and western portions of the area. Associated with them are the Childs-Aldwinkle, American Eagle, Copper Prince, Copper Giant, Old Reliable, Globe, and numerous other breccia pipes. The faults of this system, characterized by considerable gouge, are believed to have resulted from shearing stresses. Most of the E.-W. faults cannot be traced for more than a few hundred feet, although one has been followed vertically for 850 feet in the Childs-Aldwinkle mine and mapped on the surface for a length of half a mile, and another extends westward for more than a mile from the American Eagle mine. Their outcrops commonly are highly silicified straight bands, ½ to 4 inches wide, stained reddish brown by iron oxide. Outcrops of some faults of this system, to the west of the American Eagle and Globe mines, locally show iron-stained quartz and sericite 3 to 4 feet wide. A few show small amounts of copper minerals.

The faults that trend N. 55 to 60 degrees E. range in dip between 75 degrees SE. and 75 degrees NW., but most of them are almost vertical. This system is strongest in the northeastern portion of the intrusive area, and it is strong also in the vicinity of the Childs-Aldwinkle mine and at numerous other breccia pipes. Outcrops of these faults resemble those of the E.-W. system in silicification and iron staining, but they contain ore minerals more abundantly. Many can be traced for 1,500 feet. The southwesterly trending Blue Bird fissure has been followed on the 525 level for 1,800 feet and has been mapped on the surface (Fig. 13) intermittently for almost a mile. The general absence of gouge in faults of this system suggests tensional forces.

Faults striking N. 65 to 75 degrees W. and dipping almost vertically are prominent in the central and northwestern portions of the area. Their outcrops characteristically are short, narrow silicified bands, stained with iron oxide. A prominent fault of this direction in the Childs-Aldwinkle mine dips 70 degrees S. and shows little gouge.

Tight vertical faults striking N. 10 degrees W. occur sparingly throughout the district and are present near most of the breccia pipes. Outcrops of some of the breccia pipes are aligned in this direction.

Faults, trending in directions other than those of the four principal systems, are present in the Copper Creek area. In the southwestern portion, a fault striking N. 55 to 60 degrees W. forms a linear silicified, iron-stained outcrop, about 50 feet wide, which resembles some of the breccia pipes. In the western part of the
area, two faults striking N. 35 degrees W. and N. 10 to 20 degrees E., respectively, are marked by a series of individual breccia pipes.

**Jointing:** Numerous joints parallel to the four principal directions of faulting occur in the andesite tuff and granodiorite.

**Breccia pipes:** The term “pipe,” as here used, refers to breccia bodies rudely circular or elliptical in plan and having great vertical extent. “Chimney” and “diatreme” also are terms used to denote such bodies. 6

From 100 to 125 breccia pipes (Figs. 13 and 14) have been noted in the Copper Creek area, only a few of which are ore bearing. They occur in strong fracture zones or at intersections of fractures. It is believed that solutions passing through these permeable zones developed the brecciation. Thus the structures resemble the type of solution chimney described by B. S. Butler. 7

**TYPES OF ORE DEPOSITS**

The ore deposits in the Copper Creek region may be classified as breccia pipe and vein deposits. The production has been largely from pipes, notably the Childs-Aldwinkle, Copper Prince, Old Reliable, American Eagle, and Globe. Numerous other pipes were prospected but failed to yield ore. The productive pipe deposits are either in, or near, the granodiorite. In the pipe deposits, copper and molybdenum sulfides are the principal ore minerals; lead, silver, and gold are very subordinate; and zinc and tungsten, so far as known, are comparatively rare. The molybdenite has been found to contain notable amounts of rhenium. 9

Many of the veins have been prospected. Several show strong mineralization, but only one, the Blue Bird, has proved to be commercial. The Blue Bird vein, like the productive pipe deposits, is within granodiorite. Most of the vein deposits, including the Blue Bird, are in the N. 60 degrees E. system of faults. The metals in the veins most commonly are lead, silver, and copper.

**ZONING**

A rough lateral zoning of metals exists in the Copper Creek region. Molybdenite appears to be restricted to a small area less than a mile in diameter, which includes the Childs-Aldwinkle, Old Reliable, Copper Prince, and several smaller pipes east and southeast of the Childs-Aldwinkle mine. Copper in this central area exceeds molybdenum in amount. Outside the molybdenum-copper center is a zone in which copper minerals predominate, and surrounding this is a zone that includes the lead-silver-copper deposits of the Blue Bird mine and several smaller lead-copper deposits. The area including the molybdenum, copper, and lead zones is approximately 2 miles in diameter.

**AGE OF MINERALIZATION**

In upper Copper Creek basin, several miles east of the area studied, strong veins containing copper, gold, and silver cut the upper basalt lava flows. The veins in the lavas have the same
general strike as those in the granodiorite and andesite tuff and generally appear to be similar. If the same forces caused the faults in the lava and in the granodiorite, the fissure veins and the pipe deposits are of the same age as the veins in the basaltic lavas.

**BLUE BIRD MINE**

*Location:* The Blue Bird mine and camp are a mile northeast of Copper Creek post office, at an altitude of approximately 4,600 feet.

*Production:* The value of production from the Blue Bird mine prior to 1926 has been estimated at $150,000, mainly in lead and silver. During 1926-39, its output of lead, silver, and copper was valued at approximately $350,000. The 598 tons of ore mined in 1948 yielded 31,200 pounds of lead, 2,100 pounds of copper, 1,085 ounces of silver, and 3 ounces of gold, valued in all at $6,021.

*Vein:* The Blue Bird vein occupies a fissure zone in granodiorite. This zone strikes N. 40 to 60 degrees E. and dips 80 to 85 degrees SE. It is from 2 to 5 feet wide and consists of numerous subparallel fissures en echelon. In many places it has been intruded by small andesite dikes.

Two distinct mineralized bodies occur in the vein. The main ore body, containing sulfides of lead, silver, copper, and iron, has been followed from the surface to the 535 level (Fig. 15) and found to pitch 45 degrees NE. The other body, containing wulfenite of sub-commercial grade, apexes near the 335 level.

The main ore zone consists of sulfide-filled fractures cutting quartz, altered granodiorite, and andesite. In many places, sulfides occur along the fault which forms the footwall of the vein, but commonly stringers of galena follow fractures crossing the vein. Along single fractures the sulfide zones are an inch or less in width, but, where several of the fractures meet, widths of 3 to 9 inches are common. The ore pinches and swells along the individual fractures, and within the ore body are barren areas. Crushing has occurred within the vein, and these areas are barren. Towards the horizontal limits of the ore body, the amount of sulfides diminishes, although the vein continues.

In general, only slight oxidation of the iron and copper minerals is apparent in the main vein.

The mineralized portion of the vein northeast of the sulfide body on the lower levels occurs within a breccia that has been followed on the 535 level for at least 200 feet. Angular to rounded, altered blocks of granodiorite, 4 to 8 inches across, surrounded and cemented by quartz, limonite, and psilomelane, occur within a zone 4 to 6 feet wide. It is similar in appearance to the initial stage of solution breccia at the Childs-Aldwinkle pipe. Small dikes have intruded the breccia. On the 335 and 435 levels, the breccia zone is adjacent to the sulfide body, but on the 535 level about 100 feet of fresh granodiorite separates the two bodies. A fault containing 2 to 4 inches of gouge, quartz, and limonite cuts the breccia zone and connects with the galena-bearing fissures of
Figure 15.—Plan and cross sections of Blue Bird mine workings. (By Truman H. Kuhn from mine map made by T. N. Stevens in 1938.)
the sulfide body. The wulfenite on the 535 level occurs with limonite, partly filling open spaces within a quartz network. Psilomelane is present as stains on quartz and as stringers generally less than \( \frac{3}{4} \) inch wide.

**Minerals:** Galena, bornite, chalcopyrite, tennantite, sphalerite, and pyrite are considered as hypogene (primary) minerals of the Blue Bird mine.

Classified as supergene minerals are: Azurite, malachite, cerargyrite, chrysocolla, limonite, native silver, anglesite, cerussite, covellite, chalcocite, stromeyerite, wulfenite, descliozite, and psilomelane.

Galena is the predominant sulfide. It replaces all hypogene sulfides, with the possible exception of bornite, as veinlets and along grain boundaries.

Sphalerite is sparingly present.

The copper content of the Blue Bird ores increases with depth, apparently because of an increase in chalcopyrite and bornite. Chalcocite occurs widely distributed through the sulfide body as veinlets and as masses up to 2 inches in diameter.

Anglesite and cerussite are more abundant and more widely distributed throughout the mine than the oxidized copper minerals. They replace galena as veinlets and along cleavage planes, and they also form crystals within vugs in the ore.

**Wall-rock alteration:** The granodiorite walls for a few feet from the vein show partial alteration to kaolin, sericite, and chlorite. Small grains of pyrite are disseminated in the granodiorite. Alteration of rock fragments within the vein is more intense than that within the walls.

**REFERENCES, BUNKER HILL DISTRICT**

5. Oral communication.
9. C. F. Hiskey, Dept. of Chemistry, Univ. of Tenn., written communication (1939).
CHAPTER VIII—BANNER DISTRICT

INTRODUCTION

The Banner mining district has been defined as the area occupied by the Dripping Spring Mountains within southern Gila County. Thus it is approximately 15 miles long by 3 to 7 miles wide.

Hayden, Winkelman, and Christmas, all served by the Christmas branch of the Southern Pacific railway, are the principal settlements in the vicinity. Hayden is the site of a copper smelter of the American Smelting and Refining Company, together with the concentrator for the Ray mine of Kennecott Copper Corporation. Winkelman is an old town near the junction of San Pedro and Gila rivers, 1½ miles southeast of Hayden. Christmas is a copper-mining camp 8 miles north of Winkelman. Via State highway 77, Winkelman is 78 miles north of Tucson and 44 miles south of Globe. A highway down Gila Valley from Winkelman extends to Kelvin. Secondary roads from these highways lead to the mines.

PRODUCTION

Production from the Banner district has been reported as follows:

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Period</th>
<th>Quantity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>1905-49</td>
<td>68,973,911 lb.</td>
<td>$12,122,140</td>
</tr>
<tr>
<td>Lead</td>
<td>1913-49</td>
<td>34,284,199 lb.</td>
<td>2,211,313</td>
</tr>
<tr>
<td>Zinc</td>
<td>1917-49</td>
<td>4,598,733 lb.</td>
<td>455,056</td>
</tr>
<tr>
<td>Silver</td>
<td>1905-49</td>
<td>702,786 oz.</td>
<td>481,377</td>
</tr>
<tr>
<td>Gold</td>
<td>1905-49</td>
<td>22,689 oz.</td>
<td>590,973</td>
</tr>
<tr>
<td>Undistributed</td>
<td>1912</td>
<td>$27,137</td>
<td></td>
</tr>
</tbody>
</table>

Total value $15,887,986

Most of the copper was produced by the Christmas mine, and some by the Schneider (Gila Canyon), London-Arizona, and Seventy-Nine mines.

The lead was largely from the Seventy-Nine mine, and to a small extent from the London-Arizona (Curtin) and Regan properties.

The zinc, except for 33,333 pounds credited to the Curtin mine in 1917, came from the Seventy-Nine mine during 1937-48.

PREVIOUS DESCRIPTIONS

The topography of the Banner district is shown on the Ray and Christmas quadrangle sheets, published by the U.S. Geological Survey on a scale of 1:62,500 and a contour interval of 50 feet.

The general geology of the Ray quadrangle was mapped by F. L. Ransome and J. B. Umpleby during 1910-11. In the Ray Folio, Ransome described some of the mines of the Banner district. The Saddle Mountain and Banner districts were studied briefly by C. P. Ross in 1922. During World War II, the U.S. Geological Survey and U.S. Bureau of Mines carried on an exploration project at the Christmas mine. More recently, detailed studies of the Seventy-Nine mine and adjacent areas were made by George A. Kiersch.

1 References are listed numerically at end of chapter.
ARIZONA ZINC AND LEAD DEPOSITS

SEVENTY-NINE MINE AREA

By George A. Kiersch

FIELD WORK AND ACKNOWLEDGMENTS

Field work by the author in the Seventy-Nine mine area occupied approximately 120 days during 1946-47. Acknowledgments are due the officials of Shattuck Denn Mining Corporation and J. E. McKay, Superintendent of the Seventy-Nine mine, for help and co-operation in this field work; H. O. Woods, formerly Superintendent of the Hayden smelter, for living accommodations and equipment; Drs. B. S. Butler and M. N. Short, of the University of Arizona, and Dr. E. D. Wilson, Arizona Bureau of Mines, for suggestions and criticisms of the manuscript.

SITUATION AND ACCESSIBILITY

The Seventy-Nine mine area is in the southern part of T.4S., R.15E., Gila and Salt River Base and Meridian. A graded road 4 miles long extends north to the Seventy-Nine mine from the Kelvin highway at Hayden Junction, 2½ miles northwest of Hayden.

PHYSIOGRAPHY

This portion of the Dripping Spring Mountains consists of two belts separated by the northward-trending Keystone fault (Fig. 16).

The western belt, bordered by Gila conglomerate on the southwest, is floored largely by faulted, southward-tilted Paleozoic beds and minor intrusive bodies. It ranges in altitude from about 2,800 feet on the west to a maximum of 4,200 feet on the north. Its rugged topography somewhat reflects the fault pattern.

The belt east of the Keystone fault rises from an altitude of about 3,000 feet on the west to 4,483 feet on Toronado Peak, southeast of the limits of Figure 16. This belt consists essentially of gently southward-dipping strata intruded by diabase and porphyry and not intensely faulted. Its topography reflects the bedrock structure.

Drainage is by intermittent tributaries of Gila River.

ROCKS

The oldest rock exposed in the area is the Younger pre-Cambrian Mescal formation of the Apache group. It rests upon intrusive diabase and consists of approximately 50 feet of limestone with 90 feet of overlying sandy beds. Above the Mescal are the Middle Cambrian Troy quartzite, approximately 400 feet thick, succeeded by 225 feet of undifferentiated shale and quartzite, probably Middle Cambrian; Upper Devonian Martin limestone, consisting of thin beds with some shale, 250 to 328 feet thick; Lower Mississippian Escabrosa limestone, a massive cliff-former, 440 to 581 feet thick; and Lower Pennsylvanian Naco limestone, thin-bedded and cherty, 385 to more than 1,000 feet thick. This entire section appears to be conformable, although separated by at least three disconformities.
Figure 16.—Generalized geologic map of Seventy-Nine mine area. (By George A. Kiersch, 1946-47.)
The character and thickness of formations exposed in North Star Gulch, 2,100 feet west of the Seventy-Nine mine, are as follows:

Naco limestone (Lower Pennsylvanian)
1). Thin-bedded blue limestone with abundant chert lenses; 50 feet.

Escabrosa limestone (Lower Mississippian)
2). Thin-bedded blue limestone with abundant chert lenses; 45 feet.
3). Thin-bedded, fine-grained blue limestone, commonly with dark to black chert lenses; weathers tan colored and forms slope; 25 feet.
4). Thick-bedded, medium-grained light-blue limestone with sparse chert lenses; crinoidal, especially in lower part; 60 feet.
5). Shaly limestone and shale with abundant chert lenses; 15 feet.
6). Thin-bedded, fine-grained light-blue sandy limestone with abundant chert lenses; forms cliff; 30 feet.
7). Thick-bedded blue limestone with tan chert lenses abundant in lower part; crinoidal in places; forms cliff; 50 feet.
8). Gray to pinkish shaly limestone and shale with abundant chert lenses; 25 feet.
9). Fine-grained blue fossiliferous limestone; beds thick in upper part, thin in lower part; 110 feet.
10). Thick-bedded light-gray limestone; forms cliff; 15 feet.
11). Thin-bedded, fine-grained, sandy limestone, alternating light-gray and blue; few chert lenses; 60 feet.

Martin limestone (Upper Devonian)
12). Thin-bedded gray shaly limestone; 30 feet.
13). Bluish-gray to pinkish shale; 20 feet.
14). Dark-green sandy shale, very thin-bedded; 70 feet.
15). Thin-bedded, fine-grained tan limestone; 20 feet to bottom of gulch.

Of these formations, Nos. 5, 8, 11, 12, 13, and 14 are regarded as favorable for ore. Also the O’Carrol beds, 35 feet thick, at the base of the Martin limestone, are potentially favorable.

Intruded into the Mescal and the lower portion of the Troy are bodies of diabase with a maximum thickness of some 400 feet in outcrops; the total thickness of the diabase is unknown, as its lower contact is not exposed. The age of the diabase at Superior was determined by Short and others as post-Middle Cambrian and pre-Upper Devonian.

Extensive andesitic to basaltic flows, pyroclastic material, and associated intrusive rocks, all of Upper Cretaceous age, occur in the vicinity of Christmas, a few miles southeast of the Seventy-Nine nine. This extensive development of basic igneous material is expressed in the Seventy-Nine area by local basalt-porphyry sills (?) and plugs and andesitic and dacitic porphyry sills. The area probably was covered by intermediate to basic flows and pyroclastics that later were removed by erosion.
Presumably during the Cretaceous-Tertiary (Laramide) interval, this region was subjected to deformation, accompanied in its later stages by intrusion of acidic dikes, sills, and plugs, probably apophyses of the Central Arizona batholith. Such bodies as the North and Main dikes of rhyolite porphyry, North Star and South dikes of monzonite porphyry, and Seventy-Nine dike of quartz-diorite porphyry were all intruded at this time.

Gila conglomerate, presumably of Pliocene age, covers much of the southwestern portion of the area. It consists largely of sub-angular to angular fragments of basalt, porphyry, andesite, quartzite, granitic rocks, and limestone, poorly sorted in a sandy and limey cement. South of the Seventy-Nine mine it includes detrital fragments of typical mineralized material, such as vein silica and garnetized limestone with specularite and copper carbonates.

**Structure**

*Folding and low-angle faulting:* The linear northwestward trend of the Dripping Spring Mountains reflects systematic structural deformation. Ransome's cross section (Fig. 17) indicates the mountain range to be a complexly faulted anticline.

Throughout the Seventy-Nine area on the southwestern flank of the range, the pre-Tertiary strata dip about 15 degrees southward, with local variations in tilted fault blocks. Compressional stresses are evidenced by bedding-plane faults and by a thrust fault exposed north of Tam O'Shanter Peak, 1½ miles north of the Seventy-Nine mine (Fig. 17).

Bedding-plane faults are indicated by gouge between thin beds at the Discovery ore body of the Seventy-Nine mine. Also, bedding plane faults may have contributed to fracturing of the lower Martin limestone, thus assisting in its preparation as a favorable host for localization of such ore bodies as those of the London-Arizona mine.

*Steeply dipping faults:* The steeply dipping faults of the Seventy-Nine area may be classified as of pre-ore and post-ore ages. Those of the earlier group were important in localizing mineral deposition. Some of the post-ore faults displaced ore bodies, and others influenced topography.

*Pre-ore faults:* The main pre-ore breaks are the O'Carroll, Keystone, Ore Body, and Reagan Camp faults, which strike between North and N. 31 degrees W. Most of these major faults are of normal type and dip steeply west. The largest, the Keystone, has a normal displacement of over 2,000 feet. The O'Carroll fault is 7,000 feet east of the Keystone fault and beyond the limits of Figure 16.

Associated with the main faults are strong shear zones which in general strike N. 60 degrees to 70 degrees E. The principal zones of shearing are between the Keystone and Reagan Camp faults. Within this large block, the most shear zones are near the Reagan Camp fault, and less occur near the Keystone fault. A few shear zones appear between the Keystone and O'Carroll faults. Field evidence indicates a negligible to small amount of vertical movement along the shear zones.
Figure 17.—Cross section through Dripping Spring Range, looking northwest. (After F. L. Ransome, U. S. Geol. Survey Prof. Paper 115, 1919.)
Probably soon after the earliest pre-ore faulting, granitic rocks of the Central Arizona batholith were emplaced. These acidic magmas invaded the weak shear zones and formed numerous dikes, sills, and irregular granitic masses in the Seventy-Nine mine area.

Following emplacement of the dikes, movement recurred along the major north-south faults. The resulting stresses fractured the numerous dikes of the area with a general shearing of N. 70 to 85 degrees E. and developed tension fissures of about N. 55 degrees E. At this time or slightly later, such displacements as the Gulch fault zone, striking nearly N. 70 degrees E., were formed. Numerous mineralized faults of this strike occur throughout the Seventy-Nine area. All of the faults trending N. 70 degrees E. show vertical displacement, with the south block generally moved relatively upward. Some of this displacement probably took place after ore deposition. This second period of pre-ore faulting shattered and made permeable the dikes and adjacent favorable limestone beds. Ore solutions closely followed the faulting, possibly even before faulting ceased.

The pre-ore faulting is postulated as of Laramide (late Cretaceous to early Tertiary) age.

Post-ore faults: The major post-ore faulting is represented by the Main and Mountain View faults which in general strike N. 35 to 45 degrees W. Apparently associated with this faulting was additional movement along some of the pre-ore faults of N. 70 degrees E. strike.

The Main fault, largest of the post-ore breaks, dips 60 degrees NE. and effects steep normal displacement of the Discovery ore body, Massive Pyrite ore body, and North dike. The Mountain View fault has a similar strike and displaces the North dike. A fault cutting the North dike in Seventy-Nine Gulch and intersecting the Ore Body fault may be of post-ore age, as are probably those faults farther east which displace the North dike.

The prominence of faults striking N. 70 degrees E. and their control over recent topography suggest some renewed activity along a limited number of the pre-ore breaks.

The main post-ore faulting occurred prior to deposition of the Gila conglomerate, as no displacement of that formation is apparent along the strike of the Main fault south of Seventy-Nine Gulch. The main post-ore faulting is believed to have occurred in Middle to Late Tertiary time.

Minor faulting and probably some tilting occurred after deposition of the Gila conglomerate. In Seventy-Nine Gulch, the Gila beds are cut by small faults and dip about 30 degrees W.

SEVENTY-NINE MINE

Historical Outline

1879. Deposit located by Mike and Pat O'Brien.
1919. Property leased by Continental Commission Co.
1920. Ore was packed on burros to the railway at Hayden Junction. Road to the mine completed in October. Owing to decline in price of lead, operations were suspended in December.

1921. Property purchased for Continental Commission Co., capitalized at $1,000,000.

1922. Production from November, 1919 to May, 1922 was 3,000 tons or ore averaging 24 per cent lead, 1.75 per cent copper, 4 ounces of silver, and 80 cents in gold per ton. Property purchased by Seventy-Nine Mining Co. in May, and production continued at rate of about 50 tons per day.

1923. Property reconveyed to Continental Commission Company after litigation.

1926. Property sold at public auction to satisfy a judgment of $16,000.

1928. Mine reopened by Seventy-Nine Lead-Copper Co. after remaining idle for about six years. More than 2,300 tons of oxidized lead ore shipped to smelter at Douglas. The property ranked fifth as producer of lead in Arizona in 1928.

1929. Production was nearly 15,000 tons of oxidized lead ore containing about 22 per cent lead, 1 per cent copper, 5 ounces of silver, and 0.05 ounce of gold per ton; property became the largest producer of lead in Arizona in 1929 and ranked thirteenth as a producer of silver. Inclined shaft was deepened to 450 feet.

1930. Mine worked only during first half of year, producing 5,400 tons of lead-silver ore and 1,700 tons of copper ore to rank second as a producer of lead in Arizona in 1930.

1936. Nearly 9,000 tons of oxidized lead ore produced. Construction started on a concentrator of 60 tons daily capacity.

1937. Concentrator treated 10,483 tons of zinc-lead ore, and 3,435 tons of lead ore were shipped.

1938. Owing to decline in metal prices, mine and mill were closed in January.

1940. Shattuck-Denn Mining Corporation reopened the mine, initiated extensive exploration on the 5th and 6th levels, and later opened up a 7th level.


1950-51. Some production by lessee.

MINERALIZATION

The known ore bodies of the Seventy-Nine mine occur as replacements in thin-bedded Naco limestone and as small discontinuous vein-replacements in the North dike of rhyolite porphyry.

Ore deposition closely followed the pre-mineral faulting and may have begun before it entirely ceased. The mineralization is regarded as of Laramide (late Cretaceous to early Tertiary) age.

DISCOVERY ORE BODY

The Discovery ore body, marked by a strong gossan, crops out immediately north of the present inclined shaft, in thin-bedded
impure Naco limestone alternating with shaly to siliceous strata. Here these beds strike N. 75 degrees E. and dip 25 to 35 degrees S. Mineralization extends throughout a thickness of about 50 feet for 300 feet along the strike, and down dip with a slight easterly pitch probably to the South dike. The Discovery ore body is cut by the post-ore Main fault on the east and appears to die out westward where the beds are less shattered and broken.

Mineralization has been selective with a preference for the fractured or broken, thin calcareous shale. This relationship of ore to shaly material is the rule throughout the Seventy-Nine mine area; nowhere was pure massive limestone replaced.

**Massive Pyrite Ore Body**

The second largest single ore body within the thin-bedded limestone-shale series is the Massive Pyrite ore body. It occurs immediately east of the Main fault which displaces it on the west between the 5th and 6th levels, and it fades out within 175 feet eastward in limestone. On the 6th level, thin shaly, calcareous beds dipping approximately 40 degrees S. have been replaced by massive pyrite with much associated silicification. The pyrite body extends south to the Seventy-Nine dike, north to the South dike, and from about 50 feet below the 6th level to 15 feet above that level. Its base-metal content has been below commercial grade.

Up dip from the Massive pyrite body, across the South dike and between the South and North dikes (Fig. 18), the alternating thin beds have been mineralized for 200 feet along their strike and vertically for about 50 feet. Mineralization has been selective in fractured or shattered thin-bedded calcareous, shaly material and is strongest up dip from the north contact of the South dike. High-grade ore was not mined up dip to the North dike but was stopped to an economic cutoff.

A large circular mass of silica 15 feet high crops out above the Massive Pyrite body, but only slight surface indications of gossan are present. Similar large silica masses occur elsewhere in the area, especially in the vicinity of the Keystone fault.

**Other Ore Bodies in Limestone**

On the 6th level, Naco limestone beds adjacent to the north and south walls of the North dike show mineralization similar to that within the dike at this locality. This mineralization roughly parallels the dike contact and nowhere extends a great distance from the porphyry.

**Dike Ore Bodies**

Mining operations since 1940 have been largely restricted to discontinuous vein-replacement ore bodies associated with the North dike of rhyolite porphyry. These deposits are on the north and south contacts as well as within the dike. West of the Ore Body fault zone, mineralization occurs along the north rhyolite porphyry-limestone contact from above the 5th to below the 7th levels. Here the igneous rock has been extensively shattered and altered.
Figure 18.—Cross section through Massive Pyrite ore body, Seventy-Nine mine, looking east. (By George A. Kiersch.)
Discontinuous ore bodies within the porphyry have been found on the 5th, 6th, and 7th levels. They consist of closely spaced stringers in extensively fractured rhyolite porphyry, associated with abundant seams of argillized material of unknown composition. This claylike material, presumably of hydrothermal origin, is less common in poorly mineralized portions of the dike. Most of the ore bodies are not connected vertically. Mineralization is largely confined to an area in the North dike near the Ore Body fault, 800 to 1,100 feet east of the shaft, with separate ore bodies at different elevations. This lateral and vertical restriction suggests that the dip of the mineralized fractures interfered with ready vertical movement of the ore solutions. The rhyolite porphyry shows much kaolinization and varying amounts of silicification.

The hypogene ores of these bodies associated with the porphyry are very similar mineralogically. Galena and sphalerite are the main minerals, with associated pyrite and minor amounts of chalcopyrite. The zinc content is slightly higher on the 7th than on the 6th level. Silver is present in galena. Oxidation reached its lower limit a short distance below the 6th level.

**Relation of Ore to Structure**

Ore-bearing solutions penetrated the more permeable shear-zone breaks and tension fractures of favorable host rocks. Thus faulting, and fracturing, combined with physical character of the wall rocks, has been the chief controlling factor in localizing the ore.

The original pre-ore faulting produced the shear zones of general N. 60 to 70 degrees E. strike. These zones were subsequently invaded by numerous granitic porphyry dikes and sills. The second pre-ore faulting consisted of renewed activity along the major north-south faults. This movement faulted, fractured, and sheared the limestone and dikes. The North dike appears to have been more intensely broken than many of the other dikes and in a manner which rendered it permeable to invading ore solutions. A few zones in the Naco also fractured in a favorable manner, but most of the limestone did not.

The relation of mineralized fractures to major faulting is clearly seen on the 6th level, east of the Ore Body fault. Tension and shear fractures resulting from this fault movement are here mineralized as sulfide stringers. Northeastward the fractures of N. 55 degrees E. trend swing into weakly mineralized N. 35 degrees E. fractures which shortly change to unmineralized fractures of nearly north-south strikes.

Presumably, ore solutions ascended along the major north-south faults. Ore solutions migrating upward along the Ore Body fault would have encountered permeable tension and shear fractures in the North dike; ores were deposited in this favorable host, but rarely in adjacent limestone. As these breaks were closely spaced, mineralization was sufficiently concentrated to form an essentially massive ore body.

The Ore Body and Keystone faults locally show some mineral stain along their outcrops. Underground, the Ore Body fault
zone was not seen to be mineralized, but mineable ore bodies occur near it.

The Discovery and Massive Pyrite replacement ore bodies apparently had an origin similar to that of the ore bodies in the porphyry. A strong suggestion of associated north-south faulting and shearing is the alignment of bending along the outcrops of the North, South, and Office dikes near the Discovery ore body. The echelon off-setting may indicate north-south faulting and a possible channelway for ore solutions. Mineralization may have penetrated upward along this north-south zone and, on encountering shattered and permeable Naco beds, migrated laterally to form the Discovery and Massive Pyrite ore bodies. Southward this zone aligns with a north-south fracture zone cutting the Long Fellow dike at a large mineral-stained area.

The north contacts and shear zones of the South and Seventy-Nine dikes may have acted as accessory ore channels for mineralization of the Discovery and Massive Pyrite ore bodies.

The main shear zones of the North dike and particularly its northern contact also were apparently ore solution. This main zone may have been one of the "avenues" for solutions migrating upward from their source, or it functioned as a near-surface "escape-route" from the major north-south faults. The North dike is known to be mineralized for 1,800 feet along its strike.

The Main fault displaces the Discovery and Massive Pyrite ore bodies. Reconstruction of the pre-faulting position of the mineralized beds with information available places the Massive Pyrite ore body higher in the geologic section than the Discovery ore body; apparently the Naco limestone has within its lower portion two zones favorable for replacement.

**Hypogene Ores**

The following discussion of the origin, association, and sequence of hypogene minerals in the Seventy-Nine mine is based on microscopic examination of representative polished sections of specimens collected from lower levels of the mine.

**Pyrite** ($\text{FeS}_2$): The most abundant sulfide is pyrite. It is most plentiful in the lower workings, especially on the 6th level. Here a massive pyrite body, cut off to the west by the Main fault, extends east and has been shown to be of sub-commercial grade. Massive pyrite bands occur along margins of the hypogene ore bodies within the North dike, and small pyrite stringers are present throughout the hypogene ore. Pyrite is appreciably less abundant on the upper levels.

The massive pyrite was probably formed by precipitation around closely spaced nuclei. Many pyrite grains show embayments of veinlets filled with sphalerite, galena, quartz, or supergene cerussite and anglesite, but no pyrite replacing these minerals was observed. Pyrite in the "exploded bomb structure" is common in the ores.

Pyrite is clearly the earliest mineral, and its deposition ceased before that of the other minerals began. Previous to base-metal
deposition, the pyrite was somewhat shattered and subsequently invaded by the second stage of mineralization.

*Sphalerite* (ZnS): Sphalerite is about equal in abundance to galena in the sulfide zone. It occurs in grains of various size, clearly later than pyrite but earlier than the other minerals. Throughout the sphalerite grains are small blebs of chalcopyrite.

Sphalerite is abundant in the lower levels, and the highest-grade zinc ore found in the mine is on the 7th level. No sphalerite occurs in the upper oxidized zone, which suggests that it was leached by acid waters and removed.

Polished sections reveal embayments and veinlets of galena in sphalerite. Some of these replacements are parallel to cleavage directions of sphalerite, indicating the sphalerite to be earlier than the galena.

The solutions rich in zinc and lead carried small amounts of copper. Precipitation of the zinc was followed almost contemporaneously by lead and less abundant copper.

*Galena* (PbS): Galena is the most important ore-forming mineral of the Seventy-Nine mine.

In the oxidized zone galena occurs altering to anglesite and cerussite; the galena is surrounded by anglesite which in turn is enclosed by cerussite.

In the sulfide zone, galena is invariably associated with sphalerite. Detailed microscopic examination shows that sphalerite is the earlier mineral, as evidenced by embayments and veinlets of galena.

*Chalcopyrite* (CuFeS₂): Chalcopyrite is a minor ore mineral in the sulfide zone. It invariably occurs associated with galena and sphalerite, although generally not recognizable in hand specimens. Microscopic examination shows small blebs and grains of chalcopyrite scattered through most specimens of sphalerite. In places chalcopyrite is present as irregular grains along cleavage contacts of sphalerite and galena and forming mutual boundaries with galena. Hence the chalcopyrite and galena are regarded as essentially contemporaneous.

*Silver*: Silver has occurred throughout the oxide and sulfide ores. In some ore bodies, the amount has greatly exceeded the average for the mine as a whole.

Microscopic examination revealed no identifiable silver mineral in the sulfide ore. The silver apparently occurs in the galena. Guild has shown that galena may absorb up to 0.10 per cent silver before the silver will form as a separate mineral. In the Seventy-Nine mine ores, the silver content amounts to less than one per cent of the total lead content; it did not precipitate out as a silver sulfide, but enriched the galena.

*Quartz*: Throughout the ore zones, quartz is an abundant gangue. It occurs as crystals filling druses and cavities; stringers and replacements in limestone and rhyolite porphyry; and massive silica bodies.
Microscopically, the sulfide ores contain quartz stringers cutting and replacing all hypogene minerals, which establishes quartz as the latest hypogene mineral.

Much silica occurs as lenses and replacement bodies, which are best seen where weathering has removed the enclosing beds and left bold outcrops of resistant silicea. Some small bodies of this type are on the surface at the Discovery ore body. A large circular mass 15 feet high, locally termed a “blowout,” occurs above the Massive Pyrite ore body. Microscopically, it shows two stages of silicification. Similar siliceous bodies are found elsewhere in the area. West of Keystone fault, south of the Chilito road, silica occurs as lenses parallel to bedding of the Naco limestone.

Specular hematite is commonly associated with some pyrite bodies.

**Oxidation and Supergene Enrichment**

The Discovery ore body is characterized at the surface by iron stain in the mineralized beds and adjacent limestone and porphyry. This strong gossan is not evident above the oxidized Massive Pyrite body and other ore bodies east of the Main fault.

In the Discovery ore body, pyrite has been rather completely oxidized, and only minor amounts of it are associated with the supergene ore. Limonite is common throughout the oxidized ore bodies. Following Blanchard and Boswell, limonite is presumed to be mostly ferric oxide monohydrate (goethite), but it may be partly ferric oxide (hematite), lepidocrocite, jarosite, or certain basic ferric sulfates.

Similar conditions apparently prevailed in the bed replacement deposits and the ore bodies associated with the North dike of the 5th and 6th levels. On these lower levels the completely oxidized zone grades downward into the hypogene sulfide zone. Demarkation of these zones is not sharp but gradational both horizontally and vertically. In cross section, the supergene zone penetrates deep into hypogene ore in places, showing the effect of increased permeability for circulating ground waters.

Supergene ore is characterized by subtraction of iron and zinc and alteration of galena with little migration of lead. It constituted most of the production prior to 1940.

**Water Table**

Water was encountered in 1946 at about 20 feet below the 7th level, or 500 feet below the present surface. As the mine was not equipped to pump this water, deeper exploration was not attempted. No measurements of the amount of water have been made.

**Oxidized and Supergene Ores**

Supergene minerals are predominant in the Discovery, Massive Pyrite, and in upper parts of the North dike ore bodies. Mixed supergene and hypogene ores occur on intermediate levels.
Most of the oxidized minerals are above the 6th level. Those recognized are:

- **Anglesite** \(\text{PbSO}_4\)
- **Azurite** \(2\text{CuCO}_3\cdot\text{Cu(OH)}_2\)
- **Brochantite** \(\text{CuSO}_4\cdot\text{Cu(OH)}_2\)
- **Cerussite** \(\text{PbCO}_3\)
- **Chalcanthite** \(\text{CuSO}_4\cdot5\text{H}_2\text{O}\)
- **Limonite** Mixture of oxidized iron minerals.
- **Malachite** \(\text{CuCO}_3\cdot\text{Cu(OH)}_2\)
- **Manganite** \(\text{Mn}_2\text{O}_3\cdot\text{H}_2\text{O}\)
- **Melanterite** \(\text{FeSO}_4\cdot7\text{H}_2\text{O}\)
- **Psilomelane** \(\text{MnO}_2\)
- **Wulfenite** \(\text{Pb Mo O}_4\)

The oxidized copper minerals are not sufficiently abundant to constitute copper ore, but some copper has been recovered from them as a by-product in lead smelting. Azurite and malachite are the most abundant of the oxidized copper minerals and occur throughout the oxidized zone. Chalcanthite and brochantite are sparingly associated with pyrite.

Melanterite associated with pyrite was found as spotty massive linings along the 6th level.

Manganese oxides, probably psilomelane and manganite, are common in the oxidized zone. Some irregular masses and much manganese stain are associated with oxidized ore, especially on the 2nd and 5th levels.

Wulfenite is sparingly present irregularly throughout the oxidized zone and most abundant on the 4th level near the Main fault. It does not occur in sufficient quantities to be ore. Wulfenite may form from oxidization of galena and molybdenite, but no molybdenite was found in the sulfide zone.

Limonite occurs as a brown stain on the limestone and gangue minerals, as small stringers in the soft gougy fault material, and as pseudomorphs after pyrite.

Anglesite is very common throughout the oxidized zone. Dark anglesite occurs as concentric rings around galena where replacement is not complete.

Cerussite is the most abundant oxidized ore mineral and constitutes rich ore throughout the oxide zone, mainly above the 6th level. It occurs most commonly as earthy white or yellowish masses, locally with a sandy texture (sand carbonate), and also in colorless crystal groups.

Lead, in contrast to zinc, has only slight mobility in the oxidized zone; lead carbonate is difficultly soluble.

**Covellite** (\(\text{CuS}\)): Minor amounts of covellite are associated with oxidation products of galena. Microscopic covellite grains with feathery edges occur along cleavage cracks in galena, as replacements within anglesite, and along anglesite-galena contacts.

**Chalcocite** (\(\text{Cu}_2\text{S}\)): Minor amounts of chalcocite are associated with the sulfide ore. Microscopically, chalcocite occurs as small grains associated with fractures within the sphalerite, and as small supergene veinlets.
MINING AND TREATMENT OF ORE

Open stoping was carried on in the near-surface bed-replacement deposits, and square-sets with fill have been used in the porphyry and deep-level bed-replacement ore bodies.

Mining operations in 1947 produced both oxide and sulfide ore. The sulfide ore, containing values in lead, zinc, copper, and silver, constituted the major output. It was trucked to Hayden Junction and shipped by railroad car to the custom mill of the Shattuck-Denn Mining Corporation at Bisbee, Arizona, where lead and zinc concentrates were made by differential flotation. Argentiferous galena and chalcopyrite were recovered as a lead concentrate in a primary flotation circuit. The lead tailing was then reconditioned to activate surfaces of the included sphalerite. The reconditioned tailing was run through a second flotation circuit, and sphalerite recovered as a zinc concentrate. The pyrite and gangue remained in the zinc tailing.

The lead concentrate was shipped to the lead smelter at El Paso, Texas, and the zinc concentrate to the zinc smelter at Amarillo, Texas.

The oxide ore, containing lead with minor amounts of copper and silver, was trucked to Hayden Junction and shipped by rail to the lead smelter at El Paso. The lower limit of grade for this shipping ore was estimated as 18 per cent of combined lead and zinc.

REAGAN CAMP PROSPECTS

Location, history, and production: The Reagan Camp claims extend from Reagan Camp on the west up Keystone Gulch and Little Chocolate Canyon to the Schneider Group on the east. They are bounded on the north by the Seventy-Nine Lead-Copper Company claims and approximately on the south by Chocolate Canyon.

Early history of the claims is not known. According to Mr. Kullum, caretaker of the property, the original claims were acquired about 1923 by Lee Reagan who was maintaining an active interest in them at the time of the writer's visit.

Production has been small and very irregular from several scattered prospects and small workings. The principal development, in Keystone Gulch ½ mile east of the camp, has produced a few carloads of oxidized lead ore which was shipped directly to the smelter at El Paso, Texas.

Geology and ore deposits: Naco limestone and a large plug of basalt porphyry crop out over most of the claims. Part of the property is east of the Keystone fault, where diabase crops out.

The best mineral showing is along the north contact of the basalt porphyry with Naco limestone. This contact, where exposed in Keystone Gulch, dips steeply north. On the south side of Keystone Gulch, ½ mile east of Reagan Camp, several adits and cross-cuts have been driven at different elevations through Naco limestone to prospect the contact.
Within the workings the thin-bedded Naco limestone shows mineralization up dip from the porphyry in a few favorable places. The ore of lead carbonate was not persistent along the contact, nor was it continuous many feet laterally into the limestone.

About ¼ mile farther east along this same contact is a large siliceous outcrop with associated iron and copper stain in Naco limestone. This mass is very similar to that on the surface above the Massive Pyrite ore body at the Seventy-Nine mine and similar to others in the vicinity of the Keystone fault. Some oxidized copper ore has been mined from workings beneath it.

East of the Keystone fault in Little Chocolate Canyon, prospecting in diabase has disclosed several small veins containing lead and copper minerals. None of these veins has been worked commercially.

**CURTIN OR HUMPRHEY MINE**

*By Eldred D. Wilson*

The Curtin mine is about 1 mile east of the London-Arizona mine and Chilito settlement, or 2½ miles east of the Seventy-Nine mine. It is accessible from State Highway 77 by 6 miles of road that branches northwestward from Finney siding between Winkelman and Christmas.

The Governor Curtin and thirty-five other claims in the vicinity were obtained by T. Z. Humphrey and associate in 1948. This ground formerly was part of the London-Arizona property. Prior to 1920, according to Ross, the Curtin vertical shaft was sunk to a depth of 325 feet. Production, mostly out of shallow workings in the vicinity, was 1,016 tons of lead ore and 51 tons of zinc ore.

When visited in June, 1948, the old Curtin shaft was caved below a depth of 100 feet. An inclined shaft 95 feet farther north had been deepened to 170 feet, and more than 1,000 feet of adit workings connecting with the shafts at the 70 level had been reopened. During the following year, some lead ore was shipped from these workings.

Here Naco (Pennsylvanian) limestone is intruded by porphyry dikes and overlain on the east by Cretaceous volcanics. The limestone beds prevailingly strike west-northwesterly and dip 10 to 20 degrees southward. About 1,200 feet west of the shaft is the O’Carroll fault, whose course is followed by a prominent southerly trending gulch. This fault brings Mississippian Escabrosa and Devonian Martin limestone on the west in contact with the Naco limestone on the east. The main porphyry dikes strike approximately parallel to the limestone, but branches of them trend northeast, northwest, and south. In general the dikes dip steeply northward, but in places they form sills more or less concordant with the limestone beds.

The ore deposits are irregular replacements in the Naco limestone. They occur mainly on the north or hanging wall side of the main dike and on the footwall side of sills. Certain impure limestone beds were relatively favorable for replacement. Most
of the northeast fissures exposed underground show mineralization.

The ore consists mainly of cerussite, anglesite, smithsonite, hemimorphite (?), and sparse residual galena, together with abundant iron oxide, andrasite garnet, and local copper stain.

REFERENCES, BANNER DISTRICT

10. Oral communication (June, 1946).

CHAPTER IX.—SILVER AND EUREKA DISTRICTS

BY ELDRED D. WILSON

INTRODUCTION

The following description has been modified from material published in Arizona Bureau of Mines Bulletin 134.1 During early 1951, several of the mines were revisited, and some additional structural features of the area were mapped.

Useful information was supplied by L. C. White, George Holmes, Kenneth Holmes, Walter Riley, and Lincoln A. Stewart. George H. Roseveare, Metallurgist of the Arizona Bureau of Mines, cooperated in part of the field work. Acknowledgements are due Luke Walker and associates, of Red Cloud Mining and Milling Company, for accommodations and data.

PHYSICAL FEATURES

The Silver and Eureka districts of southwestern Yuma County are in T.3 and 4.S., R. 22 and 23 W., within the southern part of the

1 References are listed numerically at end of chapter.
Trigo Mountains. The area is bounded on the east by Yuma Wash and on the west and south by a bend in the Colorado River.

Commonly the Silver district on the north is regarded as separated from the Eureka district on the south by an indefinite boundary approximately 3 miles from the Colorado River. In some statistical reports, however, the two districts are considered as a unit.

The topography of this southern part of the Trigo Mountains is shown on the U.S. Army Picacho quadrangle topographic sheet which was published in 1945 and revised by the U.S. Geological Survey in 1951.

Characteristically, the terrane as a whole is remarkably rough, although its differences in altitude are not great. Irregular steep-sided peaks and serrated ridges alternate with canyons or valleys that are several hundred feet deep and drain southward or westward to the Colorado River. The river here is at an altitude of 200 feet, and the mountains extend 1,200 or more feet higher.

Water has been found in only one of the mines, the Red Cloud, where it stands at a depth of about 400 feet below the surface. Near the river, water is obtainable from shallow wells.

By road, the Silver district is some 58 miles from Yuma or 36 miles from Dome, a station on the Southern Pacific railway. The Eureka district may be reached from the mouth of Yuma Wash, on the Silver district road about 50 miles from Yuma, by boat and trail, or by boat from Picacho, California.

ROCKS

Schist and granite: The oldest rocks of the Trigo Range are of metamorphic type, mapped on Figure 19 as schist. Locally, this unit includes some areas of gneiss. Much of the schist is moderately fissile and consists of fine-grained quartz, sericitized feldspar, and bands of partly chloritized biotite.

Intruding the schist and gneiss are irregular masses of granitic rocks which weather into steep slopes. These "granites" include two or more varieties of which one is light gray and another dark gray. Examined microscopically in thin section, the lighter colored variety is seen to consist of an aggregate of quartz, feldspar, and biotite, in grains up to 0.15 inch in diameter; as the feldspar is about half orthoclase and half albite, the rock is a sodic granite. The dark-gray variety, characterized by relatively abundant biotite, other ferromagnesian minerals, and altered feldspar, is provisionally classified as granodiorite.

The schist and granite are intruded by dikes of aplite, pegmatite, and various dark-colored porphyries of intermediate to basic composition.

On the uncertain basis of their lithologic resemblance to rocks of known pre-Cambrian age, the schist and granite are presumed to be pre-Cambrian. Possibly some varieties of the "granite" are Mesozoic or early Tertiary.

Volcanic rocks: Unconformably overlying the schist and granite is a thick, extensive series of volcanic flows, breccias, and tuffs,
Figure 19.—General geologic map of silver district.
locally intruded by dikes of rhyolitic, intermediate, and basic composition.

The flows in the immediate area consist mainly of andesite, trachyte, and rhyolite. Basalt caps prominent mesas northeast of the Clip mine. The flow-breccias are mainly andesitic and trachytic. The tuffs are white, pink, buff, or locally banded.

Except that the basalt is youngest, the sequence of the several volcanic members is not adequately known. The tuffs seem to represent an upper portion of the section, with rhyolite both above and beneath them. Provisionally, the basalt is regarded as Quaternary, whereas the pre-basalt volcanics are older than the principal mineralization and probably late Cretaceous or Tertiary.

STRUCTURE

This region has undergone intense crustal disturbance during several geologic periods. As the rocks are of indefinite age, there is little direct evidence for correlating the various structural events or the associated igneous activity and mineralization.

The older metamorphic rocks reflect ancient folding and faulting upon which later structural deformation has been superimposed. Their foliation commonly strikes either northwest, northeast, or northward but is subject to local variations.

The granite has been broken by several systems of fractures of which the most prominent trend parallel to the ridges. In places, the schist and granite are separated from the volcanic rocks by faults, also subparallel to the ridges. As the main ridges of schist and granite were initiated prior to eruption of the volcanics, it is presumed that these faults represent renewed movement upon ancient, pre-volcanic breaks.

The volcanic rocks prevailingingly strike northwesterly and dip northeastward at medium to low angles. Southeast of the Red Cloud mine, however, they appear to lie in a broad, low anticline of which the axis trends approximately S. 70 degrees E.

Faults are conspicuous in many places where they separate volcanic rocks from granite and schist, but elsewhere they may be obscure at the surface. Much of the faulting was earlier than the lead-zinc-silver mineralization, and some probably was later.

As shown on Figure 19, the principal faults strike irregularly north-northwestward and dip from 35 degrees to vertically. Branches from them strike N. 20 to 30 degrees E. Less conspicuous breaks strike S. 60 to 70 degrees E. and commonly offset the N.-NW. faults. In addition, there are northeast and northwest fissures along which little or no movement has occurred.

Displacements on the faults probably range up to several hundred feet; the exact amounts are difficult to estimate, owing to the fact that the pre-volcanic erosion surface of the granite and schist was very rugged.

HISTORY OF MINING

As the Trigo Mountains are near the Colorado River, prospecting in them was carried on at a relatively early date. Mineral deposits
in the Silver and Eureka districts became known during the sixties of the past century.

According to Raymond, the Eureka district was organized in 1862, and prior to 1870 had yielded notable amounts of argentiferous galena ore from veins near the river. Only intermittent, small-scale mining has been done within the Eureka district.

Hamilton states that the Silver district was abandoned soon after its discovery and remained idle until about 1879, at which time George Sills, Neils Johnson, George W. Norton, and Gus Crawford relocated many of the abandoned claims and organized the district. The Black Rock, Pacific, Papago, Red Cloud, Silver Glance, Hamburg, and Princess deposits were among the early locations, and the town of Silent, named after the Silent claim, was established near the Red Cloud mine. Ores were freighted down a sand wash to Norton’s Landing, on the Colorado River, and shipped by boats to the Selby smelter at San Francisco. A small smelter is reported to have been built near Silent in 1880, but it operated only intermittently for about three years.

During the early eighties, a silver bonanza was discovered on the Silver Clip claim, 5 miles north of Silent. A 10-stamp mill, erected at the river northwest of the mine, was put into production by 1883. The town of Clip grew up around this mill.

In 1883 owners of the Black Rock mine erected a small furnace at the river and turned out lead bullion.

Other properties in the area produced during the early eighties, and by 1884 the Silver district was the foremost in Yuma County.

The activity, however, diminished along with depressed silver prices during the early nineties. Relatively little mining has been done there since that time, and the towns of Silent and Clip have long since passed out of existence. Favorable metal prices encouraged renewed operations at various periods, as mentioned on subsequent pages.

**PRODUCTION**

The total output of the Silver district is not accurately known. In the following table, data for the years prior to 1906 are based partly on statements in various publications and partly on estimates given in Arizona Bureau of Mines Bulletin No. 134. Figures for 1929-49 were compiled by R. T. Moore from annual volumes of the U.S. Mineral Resources and U.S. Minerals Yearbooks.

**VEINS**

Silver district: The principal veins of the Silver district occur within subparallel fault zones which strike north-northwest and dip from 35 degrees to almost vertical. They range in width from less than a foot up to 30 or more feet, and some of them are traceable for lengths of several hundred feet. Their ore shoots appear to be related to intersections of northeast fissures with the fault zones. Their principal production has come from depths of less than 250 feet below the surface.

The gangue of the veins consists mainly of banded calcite, fluorite, quartz, and barite, the order of deposition of which ap-
### PRODUCTION OF SILVER, LEAD, AND ZINC, SILVER DISTRICT

<table>
<thead>
<tr>
<th>Years</th>
<th>Tons of Ore</th>
<th>Silver Ounces</th>
<th>Silver Value</th>
<th>Lead Pounds</th>
<th>Lead Value</th>
<th>Zinc Pounds</th>
<th>Zinc Value</th>
<th>Total Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1880</td>
<td>?</td>
<td>30,000</td>
<td>$34,500</td>
<td>300,000</td>
<td>$15,000</td>
<td>49,500</td>
<td>Red Cloud</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1881-85</td>
<td>?</td>
<td>270,000</td>
<td>302,400</td>
<td>800,000</td>
<td>36,000</td>
<td>338,400</td>
<td>Red Cloud, Black Rock, Pacific, Engineer, Emma, Silver Plume, Remmnmant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1883</td>
<td>?</td>
<td>146,000</td>
<td>160,600</td>
<td>160,000</td>
<td>Clip or Blaine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1884-87</td>
<td>?</td>
<td>914,000</td>
<td>950,000</td>
<td>950,000</td>
<td>Clip or Blaine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1887</td>
<td>?</td>
<td>124,200</td>
<td>121,718</td>
<td>400,000</td>
<td>18,000</td>
<td>139,716</td>
<td>Red Cloud, Black Rock (Mint report)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1888</td>
<td>?</td>
<td>13,248</td>
<td>12,453</td>
<td>104,345</td>
<td>4,591</td>
<td>17,044</td>
<td>Red Cloud</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1889</td>
<td>?</td>
<td>22,500</td>
<td>21,150</td>
<td>300,000</td>
<td>11,700</td>
<td>32,850</td>
<td>Red Cloud concs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1929</td>
<td>700</td>
<td>7,000</td>
<td>3,731</td>
<td>3,731</td>
<td>Clip</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1934-37</td>
<td>286</td>
<td>580</td>
<td>442</td>
<td>21,414</td>
<td>1,145</td>
<td>1,587</td>
<td>Mainly Red Cloud.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1941</td>
<td>3,300</td>
<td>27,786</td>
<td>19,759</td>
<td>315,000</td>
<td>17,955</td>
<td>37,714</td>
<td>Red Cloud</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1947-49</td>
<td>1,867</td>
<td>3,887</td>
<td>3,518</td>
<td>88,300</td>
<td>14,773</td>
<td>20,052</td>
<td>Mainly Red Cloud dump in 1949</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1879-1949</td>
<td>?</td>
<td>1,559,201</td>
<td>$1,630,269</td>
<td>2,329,059</td>
<td>119,164</td>
<td>1,761</td>
<td>$1,757,194</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks:
- Census report
- Red Cloud
- Red Cloud, Black Rock, Pacific, Engineer, Emma, Silver Plume, Remmnmant
- Clip or Blaine
- Clip
- No production rptd.
- Mainly Red Cloud.
pears to be quartz, fluorite, later quartz, calcite, barite, and later calcite. Their metallic minerals are chiefly limonite, hematite, jarosite, pyrolusite, cerussite, anglesite, smithsonite, calamine, willemite, argentiferous galena, wulfenite, vanadinite, yellow lead oxide, and cerargyrite. The zinc minerals are abundant only in the southern part of the district. Argentite is reported to have been mined from some of the veins, and the silver within the galena probably occurs as microscopic inclusions of argentite. No sulphides other than galena were noted in the present work­ings; prior to oxidation, pyrite and sphalerite were doubtless locally abundant.

The galena is regarded as of hypogene or primary origin. Its secondary products, cerussite and anglesite, have been formed by oxidation essentially in their present positions.

In the abundant carbonate gangue, the zinc probably has not undergone much downward migration.

The cerargyrite, richest near the surface and in association with manganese dioxide, was apparently a product of supergene enrichment.

Recent tests by George H. Roseveare, Metallurgist of the Arizona Bureau of Mines, indicated that much of the silver occurs in a form not amenable to flotation or cyanidation, possibly as a silver manganese or silver-manganese silicate. Concentration of the oxidized ores by standard methods of gravity, flotation, and cyanidation yielded approximately 55 per cent of the silver, 80 per cent of the lead, and 20 per cent of the zinc.

Wall-rock alteration along these veins consists of pronounced chloritization and carbonatization, with relatively less sericitization and silicification.

**Eureka district:** The veins of the Eureka district seen by the writer occupy fault zones that strike about S. 70 degrees E. and dip 45 degrees or more NE. The veins range in width from less than a foot up to a general average of perhaps 3 feet and in a few spots swell to widths of 20 or more feet. Some of them are traceable for nearly a mile, but the ore shoots so far found are rather pockety and tend to be localized in the vicinity of fissures that intersect the main faults at small angles. The vein filling consists predominantly of manganiferous to ferruginous and white calcite, intermingled with masses of breccia and gouge. In places very cellular, crystalline white quartz occurs.

The ore shoots consist of limonite, hematite, cerussite, and smithsonite, with scattered bunches and narrow veins of galena and ferruginous black sphalerite. Locally a few thin streaks of copper stain appear. The vein walls contain abundant small pyrite metacrysts and show pronounced sericitization together with less abundant silicification and chloritization.

**MINES**

Although the principal lead production of the Silver and Eureka districts has come from the Red Cloud and Black Rock mines, lead
mineralization occurs also in most of the other mines and prospects of the area, as described in Arizona Bureau of Mines Bulletin No. 134.¹

Nonsulfide zinc appears to be more abundant than lead in some of the deposits.

**Red Cloud Mine**

*History and production:* The Red Cloud claim was one of the earliest locations in the Silver district. According to Hamilton,⁴ early operators took more than $30,000 worth of silver ore from the croppings. Hamilton⁵ also states that prior to 1881 the mine was purchased by Red Cloud Mining Company, of New York, which sank an incline following the dip of the vein for 274 feet and erected a furnace of 20 tons daily capacity at the Colorado River. This plant was operated intermittently for about three years. In 1885 the claim was surveyed for patent for Horton and Knapp. Later it was acquired by Hubbard and Bowers who in 1889 shipped dry concentrates which yielded 300,000 pounds of lead and 22,500 ounces of silver, valued at $32,850.

As indicated in the table on page 88, most of the production from this mine was made during 1879-89, but the amount is not known.

In 1917 the Red Cloud Consolidated Mines Company acquired the property and installed a small dry concentrator. This mill burned down before making more than a few test runs.

During 1925-26, E. R. Boericke (Primos) Company ran exploration workings on the 500 level and diamond drilled at least two holes from that level, but attempted no production.

In 1928, Neal Mining Company acquired control of the Red Cloud, together with forty-five other claims in the district, and carried on extensive sampling.

For a few months during 1941, Penn Metals, Inc., operated a newly constructed flotation plant at the mine. It treated approximately 3,300 tons of dump material which yielded 27,786 ounces of silver, 315,000 pounds of lead, 9 ounces of gold, and 500 pounds of copper, in all valued at $38,088.⁶

During 1948, George Holmes and Walter Riley diamond drilled a hole from the 500 level.

In 1950 the Red Cloud and numerous other claims in the district were acquired by Red Cloud Mining and Milling Company.

*Vein and workings:* The Red Cloud mine is at an altitude of approximately 750 feet. Its vein occurs within a fault zone which here strikes about N. 15 degrees W. and dips 35 to 60 degrees E. Irregular shafts, drifts, and stopes have followed it for a length of some 560 feet and to a depth of approximately 535 feet on the incline, as shown by Figure 20. Most of the upper workings were run before 1885 by hand drilling; the ore was sorted and screened underground and dragged up inclines with rawhide buckets. Stopes were supported by pillars, dry-wall backfills, cottonwood timbers, and willow laggings which are still fairly intact. A more vertical shaft approximately 200 feet deep reached the vein at the
270 level of the incline. The 500 level, immediately above the present water table, is reported to have been run about 1925.

The vein is made up chiefly of limonite, hematite, quartz, fluorite, and calcite, together with considerable amounts of gouge and brecciated wall rocks, all more or less stained by pyrolusite. The quartz forms irregular, finely crystalline, vuggy masses which in places are cut by veinlets or coarser-grained quartz. Commonly the quartz is interbanded with gray to purple fluorite which ranges in texture from dense to crystals $\frac{1}{8}$ inch in diameter. The calcite is mostly a coarsely crystalline, dark-gray manganiferous variety, but some later white calcite also occurs. The limonite and hematite, which occupy cavities and vugs within the other gangue minerals, are locally intermingled with irregular, cellular masses and vug-linings of cerussite, smithsonite, willemite, pyrolusite, vanadinite, wulfenite, and malachite. In places there are nodules of argentiferous galena, partly altered to black anglesite and pale-yellowish cerussite. Cerargyrite is present as small disseminated masses and streaks within the oxidized minerals.
Except in the 500-level crosscuts, the vein walls are largely concealed behind fault gouge and breccia. The limited exposures indicate that the hanging wall from the surface down to approximately 360 feet on the incline is andesitic breccia and tuff. From there to the 500 level, the hanging wall consists largely of brecciated granitic and volcanic material, and in the 503 cross-cut it is granite with faulted volcanics locally above (Fig. 21).

The footwall consists of the "granite" described on previous pages. Here this rock is brecciated and faulted for widths ranging from a few feet to 100 feet or more. Where exposed on the
surface immediately west of the mine workings, the breccia is largely cemented by calcite and quartz, together with other vein minerals.

As indicated by stoping, the vein contained two principal ore shoots, each from 1½ to 6 feet wide, near or adjacent to the hanging wall. The northern shoot was from 25 to 100 feet long by 4½ feet deep, and the southern from 35 to 110 feet long by 300 feet deep (Fig. 20). In the vicinity of these ore shoots, the vein shows relatively more iron and manganese mineralization, and its walls are intersected by northeast fissures.

According to Robert Morgan, sampling by the Neal Mining Company indicated that the unmined portions of the vein exposed in the workings above a depth of 360 feet on the incline contained an average of approximately 6 per cent lead and 10 ounces of silver per ton, but below that level the lead and silver contents were somewhat less.

It is estimated that the unmined material exposed in the workings contains more zinc than lead. This zinc, however, is in non-sulfide minerals.

The portion of the vein between the stopes and the footwall seems to be relatively low in lead and silver, but it has not been sufficiently explored to determine its over-all grade. Strong non-sulfide zinc mineralization is apparent near the footwall in the 500-level crosscuts.

Oxidation extends for an unknown distance below the present water level and was present in the Holmes-Riley drill core for more than 200 feet below the 500-level (Fig. 21).

An interesting possibility regarding the Red Cloud vein structure was suggested by Hershey. He postulated that a post-mineral fault, coinciding in places with the hanging wall, displaced portions of the vein laterally and downward.

**BLACK ROCK MINE**

**Situation and history:** The Black Rock mine is at an altitude of 750 feet, beside the main road of the district and about a mile southeast of the Red Cloud.

The Black Rock claim, one of the early locations in this region, was patented during the eighties. Few details of its history and production are known. By 1881, according to Hamilton, the mine had been sold for $135,000, and some rich ore produced from a 100-foot shaft. Prior to 1884 this shaft had been deepened to 420 feet and a small furnace for smelting the ore had been built at the Colorado River. How long this furnace operated is not recorded, but it was reported as turning out a ton of base bullion per day in June, 1883. So far as known, the mine has been worked very little since 1887. In 1948 a gravity mill of approximately ½ tons hourly capacity was built near the junction of Yuma Wash and the Colorado River, 9 miles by road southeast of the Black Rock mine. This plant, operated by George Holmes and Walter Riley until June, 1949, is reported to have treated material from the Black Rock dump.
**Geology:** The prevailing rock on the Black Rock claim is schist which consists of fine-grained quartz and sericitized feldspar, alternating with bands of partly chloritized biotite. Its principal lamination strikes northwest and dips steeply northeast. East of the mine, the schist is in fault contact with volcanic rocks. Complex faulting and fracturing have affected this schist.

**Vein:** The Black Rock vein occurs within a fault zone that strikes N. 65 degrees W. and dips 40 degrees NE. It forms an irregularly arcuate outcrop which, continuing northward onto the Silver Glance claim, is traceable for more than 2,000 feet. The vein consists mainly of manganese-stained calcite and silicified breccia which on the Black Rock claim shows a maximum width of about 18 feet. Particularly near the hanging wall, it contains honeycombed and vuggy masses of fine-grained brownish-gray quartz, fine-grained fluorite, and later vitreous quartz. Where seen in the workings, the ore shoot occurs where several northeast fissures intersect the vein. The ore consists of irregular masses of limonite, calcite, pyrolusite, smithsonite, willemite, cerussite, anglesite, yellow lead oxide, and minor galena. This mineralized portion of the vein has been followed underground for a maximum length of 175 feet and a depth on the incline of 270 feet. Its richer portion ranges from thin streaks to a width of probably not more than 10 feet, but some silver-lead-zinc mineralization is traceable throughout the width of the vein. Several quartz-fluorite stringers occur near and parallel to the large vein and are cut by branching veinlets of later calcite. For some 50 feet on each side of the main vein, the schist shows pronounced silicification, chloritization, and carbonatization.

The principal workings on the Black Rock claim include an inclined shaft 420 feet deep (Fig. 22) and more than 900 feet of drifts and tunnels. The vein, as exposed above the 270 feet level in these workings, was sampled prior to 1930 by F. W. Giroux. According to C. E. Batton, at that time owner of the property, these samples contained an average of 4.87 per cent lead, 9.8 per cent zinc, and 6.7 ounces of silver per ton.7

**Pacific and Mandan Claims**

The Pacific claim, which joins the Black Rock on the northwest, was surveyed for patent in 1887 for M. L. Keith. It has produced some silver-lead ore, but its history is unknown. Here, schist similar to that which occurs on the Black Rock claim is intruded by granite, as shown in Figure 19. The principal mineralization occurs within a silicified fault zone that strikes north, but swings southeastward on the Mandan claim, and dips about 85 degrees E. Prior to 1887, a shaft 100 feet deep was sunk where this zone is exposed on the northern bank of Black Rock Wash. Its dump shows finely crystalline, banded quartz together with masses of limonite, hematite, pyrolusite, and calcite. Some vugs in the quartz are lined with crystalline cerussite.

On the Mandan claim, which joins the Pacific on the southwest, several small cuts have been sunk on the vein. One of the ex-
Figure 22.—Principal workings of Black Rock Mine. (From map supplied by C. E. Batton in 1930.)
poses a few small nodules of altered galena. At a point near the southwest corner of the Pacific claim, the vein has been cut off by a transverse fault.

**Papago Mine**

The Papago workings are approximately 3,000 feet south of the Red Cloud and near the edge of Black Rock Wash. They are reported to have produced silver-lead ore during the early days, but no record of the amount is available. So far as known, the property has been inactive for a long time, except for an attempt made years ago to treat part of the dump by tabling and cyanidation.

In this vicinity, tuffs and andesitic lavas on the east are separated from granite on the west by the Red Cloud fault zone, as indicated on Figure 19. The Papago vein, which occurs within this fault zone and one of its north-northwesterly branches, is almost entirely mantled by surface gravels.

Workings on the Papago include four or more shafts, distributed over a length of 250 feet, with an unknown amount of drifts and stopes. They are partly filled with wash gravel, caved, or otherwise inaccessible. An assay map made by L. C. White in 1925 shows the southern or Discovery shaft to be 200 feet deep on a northeasterly incline of 40 to 65 degrees, connecting with some 250 feet of drifts and a few small stopes; the No. 2 shaft, 100 feet farther northwest, was caved below a depth of 50 feet, at which level it connected with an area of stopes extending approximately 100 feet along the strikes and 10 to 20 feet down the dip.

As indicated on Mr. White's assay map, the vein exposed by these workings ranged from 1 to 7 feet thick, 0.1 to 7.83 per cent in lead, and 1.10 to 17.60 ounces per ton in silver content. The dumps suggest that the ore was similar to that of the Red Cloud mine, but more manganiferous.

**Riho Vein**

The Riho vein is south of the Papago mine, as indicated on Figure 19.

This ground, formerly known as the Pecheco, was worked during the early days but has remained essentially idle for several decades. A few years ago, George Holmes and Walter Riley re-located three claims on the vein and built two access roads leading from Black Wash. In 1951 the property was held by Red Cloud Mining and Milling Company.

Here the prevailing rock is deformed schist, intruded by dikes of acidic to basic composition and invaded on the west by granite.

On the south claim, the vein strikes N. 30 to 40 degrees west and dips almost vertically. Northward it pinches out and branches but is traceable intermittently into the north claim where it strikes N. 15 degrees W. and dips 45 to 60 degrees east.

The vein material consists largely of calcite and white quartz, together with a little barite and nodular masses of cerussite and galena. The calcite is mainly massive and white, but in part gray and manganiferous. The quartz is fine-grained and banded to
ARIZONA ZINC AND LEAD DEPOSITS

Vuggy. In places the vein shows iron and copper stains.

Workings on the south claim include several pits, open cuts, shafts, and stopes. Apparently the shafts do not exceed 50 feet in depth, and the visible stopes are 2 to 4 feet wide.

At the north claim the vein has been stoped from several adits throughout a vertical range of approximately 75 feet on the north side of a deep, narrow ravine. These workings are now largely caved or filled but apparently extended for about 150 feet horizontally, to where the vein terminates at a steeply northeastward-dipping fault that strikes N. 65 degrees W. The stopes along the outcrop are 2 to 4 feet wide.

RIVERVIEW CLAIMS

The Riverview group of claims is in the Eureka district, a short distance north of the Colorado River.

Intermittent small-scale mining has been done here since about 1875, and occasional small shipments of high-grade silver-lead ore and hand-jig concentrates have been made. At one time a small concentrator, equipped with crusher, ball mill, and Cammett table, was erected, but it operated for only a short while. Water was obtained from a shallow well near the river.

Workings on these claims in 1930 consisted of numerous open cuts, several hundred feet of tunnels, and a few shallow winzes and shafts, mostly on veins of the type described on page 87. The tunnels contained several small stopes, one of which was about 45 feet high, 6 to 8 feet wide, and 6 to 10 feet long. According to J. L. Griffith, a test shipment made in 1927 of 16½ dry tons of concentrates from about 100 tons of ore from these workings contained 60.4 per cent lead, 8.7 per cent zinc, 6.9 per cent sulfur, 3.0 per cent iron, 27.7 ounces of silver, and 0.08 ounces of gold per ton.

MENDEVIL CLAIMS

The Ysidro Mandevil group of claims is in rugged country east of the Riverview and within a mile of the Colorado River. According to Mr. Mandevil, these claims have produced argentiferous lead ore and in 1929 yielded a few tons of sorted ore and concentrates valued at about $80 per ton. A small mill, consisting of crusher and table, was located at the river.

These claims were not visited by the writer, but the ore being milled resembled that from the Riverview.

REFERENCES, SILVER AND EUREKA DISTRICTS

2. Based partly on unpublished notes of J. B. Tenney.
5. P. Hamilton, Resources of Arizona, 1881 ed., p. 73.
7. Oral communication (1930).
CHAPTER X.—CASTLE DOME DISTRICT

By ELRED D. WILSON

PHYSICAL FEATURES

The Castle Dome district of Yuma County is 35 miles in air-line northeast of Yuma and about 6 miles by graded road east of the paved highway that leads from Yuma to Quartzsite.

The principal lead mines of the district are within a north-westerly trending area approximately 3 miles long by 1½ miles wide in the southwest pediment and foothill area of the Castle Dome Mountains. North and east of this area, the range rises steeply to heights of 1,000 to 2,000 feet above the adjacent plains and is particularly rugged. No adequate topographic map of the district is available.

ROCKS

The Castle Dome Mountains are made up of a basement of schist, gneiss, granite, and weakly metamorphosed sedimentary rocks, all intruded by dikes of diorite porphyry and overlain by a thick series of lavas cut by dikes of rhyolite porphyry. The general geology of the range is shown on Plate I of Arizona Bureau of Mines Bulletin 134.¹

Schist: The oldest rocks exposed are schists that comprise two areas totaling several square miles in the southern portion of the range. These outcrops form narrow, rolling surfaces alternating with sharp ridges that generally mark the location of steeply dipping dikes.

On the basis of their extreme metamorphism, these schists have been regarded as pre-Cambrian, but definite evidence as to their age is lacking. In places, they contain gold-quartz veins from which very little ore has been mined.

Gneiss: Associated with the schist in the southeastern portion of the range are considerable areas of gneiss. This rock is typically coarse grained, with phenocrysts of quartz and feldspar as much as ¼ or ½ inch in diameter. It is rudely laminated by prominent bands of scaly biotite, but on weathered slopes this lamination is not apparent, and the rock resembles granite.

Field relations indicate that the gneiss was originally a granite that intruded the schist. Its age has been regarded as pre-Cambrian. It contains a few small quartz veins, but no known mineral deposits of economic importance.

Granite: Medium-grained biotite granite crops out in a small area 2 miles northeast of Thumb Butte and as a small mass at the Sheep prospect, in the southeastern portion of the range. This granite, which unconformably underlies the Cretaceous (?) sedimentary rocks and intrudes the schist and gneiss, may be either pre-Cambrian, Mesozoic, or early Tertiary in age. Only a few small gold-quartz veins are known to occur within it.

¹ References are listed numerically at end of chapter.
Chloritized, epidotized syenite of unknown age crops out in a small area southeast of the Big Eye mine, on the east slope of the range.

Cretaceous (?) rocks: A thick series of well-bedded sedimentary rocks, for the most part weakly metamorphosed, rests unconformably upon the granite. These rocks make up an irregular area 9 miles long by 8 miles wide in the southern portion of the range. They constitute the principal formation in the Castle Dome district and extend southeastward to Thumb Butte, whence they continue eastward nearly across the range, to where they are faulted against schist. Almost every exposure of them contains numerous dikes of diorite porphyry and rhyolite porphyry.

These sedimentary rocks consist predominantly of greenish-gray thick-bedded shale and impure cherty limestone, locally with maroon shale and fairly pure limestone. Gray to brown arkosic sandstone, quartzite, and conglomerate are abundant in places. The gray shale contains considerable alumina and some magnesia, but very little lime carbonate. Examined microscopically in thin section, it is seen to be made up of very small, rounded to angular grains of quartz, orthoclase, and sodic plagioclase, embedded in a turbid matrix. Chloritic patches are locally plentiful. In the vicinity of the rhyolite porphyry dikes, sericitic alteration is evident, and pyrite metaocrysts, more or less changed to limonite, are abundant. Locally, as in the southeastern portion of the area mapped on Figure 23, the sedimentary beds are markedly schistose.

The total thickness of the beds can not readily be measured, but it clearly amounts to more than 1,000 feet. As no diagnostic fossils have been found within them, their age can only be inferred on the basis of lithologic similarity to other formations in the Southwest. Thus, where strongly metamorphosed, the series might reasonably be regarded as pre-Cambrian, but, where weakly metamorphosed, it bears striking resemblances to the Cretaceous rocks of southern Arizona. It is practically identical to a formation occurring 30 miles farther north in the New Water Mountains, within which are conglomerate pebbles derived from rocks of Cambrian-Middle Permian Age.1,2

The Cretaceous (?) beds of the Castle Dome Mountains are host rocks for argentiferous galena and fluorite veins in the Castle Dome district and for copper-bearing veins near Thumb Butte.

Dike rocks: The district, particularly in the western portion, contains remarkable assemblages of dikes (Fig. 23) principally of dioritic and rhyolitic composition. The former variety appears to be older, and the latter is younger, than the lavas. Their outcrops generally form ridges from low relief up to 50 or more feet high.

The diorite porphyry weathers chocolate brown to gray, mottled with white spots up to about 0.10 inch in diameter. Microscopically it consists of phenocrysts of feldspar, quartz, and biotite, set in a microcrystalline groundmass of feldspar and quartz. The quartz phenocrysts, which are relatively few, show corrosion by the groundmass. The feldspar is oligoclase-andesine.
Figure 23.—Geologic map, Castle Dome district, Yuma County (1930).
The rhyolitic porphyry weathers reddish brown and shows phenocrysts of quartz in a dense, stony groundmass. Microscopically it consists of phenocrysts of sodic plagioclase, orthoclase, and quartz, in a spherulitic groundmass that corrodes the quartz. Wherever observed, this rock is more or less sericitized and contains pyrite metacrysts.

Volcanic rocks: Volcanic rocks of probable late Cretaceous or Tertiary age make up the major portion of the Castle Dome Mountains. In places, the erosion surface of the older rocks upon which they rest shows a relief of 200 or more feet. These volcanic rocks, which have not been studied in detail, include rhyolite, andesite, tuff, and obsidian, with a total thickness of more than 2,000 feet. In places, they are covered by several hundred feet of basalt, probably of Quaternary age. Locally, the volcanic rocks are cut by dikes of and large irregular masses of rhyolite porphyry.

The older flows contain a few gold-quartz veins of economic importance, but the basalts, so far as known, are barren of mineral deposits.

STRUCTURE

The Cretaceous (?) sedimentary rocks predominantly strike northwesterly and dip 30 to 70 degrees SW., but many local differences obtain.

As a rule the dikes dip steeply and strike parallel to the principal lamination, jointing, or bedding of the formation that they cut.

The volcanic rocks prevailing strike subparallel to the trend of the range, but they show many local departures. In the central portion of the range, they dip at angles of less than 30 degrees SW. Along the Stone Cabin-Kofa road, their dips are northeast. In the southern portion of the range, other directions of dip are common. Thus the mining area and the middle segment of the range east of it appear to lie within a broad, eastward-pitching anticline. Within the area of this anticline, the rocks show relatively light-colored alteration.

The basalts are essentially flat or dip at angles of a few degrees.

The range as a whole is probably bounded by great faults that lie outward from margins of the pediments. In the Castle Dome district the principal known faults strike north-northwesterly, dip steeply, and are followed by mineral-bearing veins. Many of the faults resulted in vertical displacements of several hundred feet, and some of them record a horizontal movement. In places minor cross-faults and post-mineral movement are evident.

VEINS

The productive veins of the Castle Dome district occur near the outward margin of the pediment, and the outcrops of the widest ones are confined mainly to the suballuvial bench of this pediment. The veins occupy steeply dipping fault zones that cut both the shale and the diorite porphyry dikes. Although well represented within both of these rocks, the ore shoots are generally best where diorite porphyry forms one or both of the vein walls. The veins
apparently favor the general vicinity of the rhyolite porphyry intrusions but tend to be poor within them. 

In general, the principal veins strike from north-northwest to northwest, as indicated by the claims and workings mapped on Figure 23, and dip steeply. Those with westward dips are the steepest. Longitudinally the veins are rather continuous, and one, the Buckeye, is traceable for about 4,000 feet but is not commercially ore bearing for the entire distance. Most of the veins are less than 5 feet wide, but the widest are as much as 12 feet across. Few of them have been productive below a vertical depth of 250 feet.

The vein outcrops are traceable as grayish-white streaks of crystalline fluorite, calcite, and barite, together with more or less gypsum and locally a little quartz. In places the croppings of gangue contain tabular to irregular masses of galena, superficially altered to anglesite, cerussite, and various lead oxides.

As seen underground the gangue of the veins consists mainly of coarsely crystalline varicolored fluorite, together with crystalline calcite, bladed to massive barite, and minor amounts of quartz. Portions of the veins show banding of the gangue minerals, but the galena occurs as sheet-like masses or irregular vein-like bunches scattered through the gangue. In places, nearly solid masses of galena 8 feet thick were mined. 

In the shallower workings, particularly, the galena is superficially altered to black anglesite, grayish cerussite, and yellow and red lead oxides. Locally channels and vugs contain hydrozincite, smithsonite, wulfenite, vanadinite, mimetite, quartz, calcite, and aragonite.

The galena recently mined contained a maximum of about 30 ounces of silver per ton, but the lead carbonate generally carries less than 6 ounces. Microscopic examination of several polished sections of the galena revealed no silver minerals.

Brush described anglesite from Castle Dome as follows:

The compact anglesite occurs in banded layers, sometimes with a nucleus of unoxidized and perfectly bright cleavable galena; while in other specimens the galena has entirely disappeared and the bands are symmetrically arranged in continuous circular or elliptical lines, as so often seen in agate. The bands or layers next the galena are frequently almost black, fading from a dark brownish-gray to a light grayish-white at the point farthest from the nucleus of the galena, and the outer layer is sometimes exteriorly coated with minute, almost microscopic, crystals of transparent colorless anglesite. The thickness of the layers of compact anglesite in the specimens examined was from $\frac{1}{2}$ to 1 inch. The specific gravity of the light colored variety was about 6.0, while some of the dark mineral gave a density as high as 6.44. The hardness is 3.

A fire assay yielded 16.87 ounces of silver to the ton, while the galena was found to contain 27.3 ounces per ton.

The vein wall rocks show pronounced alteration to quartz, calcite, and sericite. Small pyrite metacrysts, more or less altered to limonite, are abundant. The shales show some chloritization.

Prospecting for veins hidden beneath surface gravels was carried on by sinking pits to bedrock and seeking the sources of nug-
gets of placer lead minerals. The early miners sank many shafts, because operations with windlasses, rawhide buckets, and hand drills permitted stoping only for distances of 25 to 50 feet from each shaft.

HISTORY

Lead-silver mining: According to Blake, the Castle Dome district was organized in 1863. He states that the prospectors of 1863 found, on many of the veins, ancient excavations from 6 to 15 feet deep and up to 100 feet long. These old workings served as reliable guides to ore. Their antiquity was abundantly shown by trees, such as iron wood and palo verde, growing in the old pits and on dumps. Well-worn trails leading to the Gila River, some 18 miles away, and the ruins there of some adobe furnaces led Blake to believe that the ores were carried from Castle Dome on the backs of Indians, during the time of either the Aztecs or the early Spanish explorers. Blake continues: "Much excitement followed the first discovery. The ore being extremely heavy and brilliant galena, with which the first prospectors were not familiar, led many of them to believe that they had found veins of nearly pure silver, and it was not until they had obtained much independent and confirmatory evidence by assays and returns from shipments that they were willing to accept the fact that the bulk of the ore was lead, carrying, however, about 30 ounces of silver to the ton."

Disappointed because the veins were not silver bonanzas, most of the prospectors went elsewhere.

For more than twenty years, mining was carried on in the district with no machinery of any kind. Except for a horse whim at one shaft, all hoisting was done by hand windlass. After careful hand sorting to a grade between 58 and 69 per cent lead and above $23 in silver, the ore was sacked and sent by teams to Castle Dome Landing on the Colorado River, some 20 miles west. From there it was taken downstream by river boats and then transferred to clipper ships for freight ing to the Selby Smelter in San Francisco.

In 1868, the ores shipped were said to contain 60 per cent lead and $40 in silver, making a value of $90 per ton. Mining and sacking cost $12, hauling to the Colorado River $15, and freight to San Francisco $18, leaving a profit of less than $45 per ton. Until about 1881, water for the miners had to be hauled from Castle Dome Landing but could be augmented at times by rain water caught in artificial and natural rock tanks. The discovery of water in some of the deeper shafts of the district provided a more adequate supply, and for several years desert travelers bought water here.

During 1870 several owners and captains of Colorado River steamboats became interested in the deposits and organized companies to exploit them. There were two principal mines, the Flora Temple, worked by Polhamus and Company, and the Castle Dome, worked by Miller and Nagle. In 1875, Captain Nagle erected a small smelter at Yuma, but, after the completion of the Southern Pacific Railroad between Los Angeles and Yuma in 1876, it was
unable to compete with the Selby Smelter. For several years afterward, the Castle Dome ores were shipped from the Landing to Yuma by railway company barges, and on to San Francisco by rail, at a total cost of $11 per ton. After completion of the Santa Fe Railroad across northern Arizona in 1883, the river boats ceased regular operations, and Dome siding, on the Southern Pacific railway, became the district’s nearest shipping point.

Because of its freedom from arsenic and antimony, this lead commanded a premium for white-lead manufacture. Blake reported the following production for 1871: Buckeye, 250 tons; Flora Temple, 400 tons; Castle Dome and Castle Dome Extension, 600 tons; and Don Santiago, 30 tons.

No comprehensive records of the production between 1877 and 1883 exist. In 1878, according to Hinton, the district contained about forty locations, nearly all of which were worked to some extent. Messrs. Miller and Hopkins had sunk shafts to a depth of 250 feet and opened stopes down to the 220 level. During the first six months of 1879, shipments to San Francisco amounted to 438½ tons, averaging 69 per cent lead and 26 ounces of silver, yielding $21,367, or an average of $48.73 per ton. For the year ending May 31, 1880, the output from the district totaled 1,100 tons, valued at $37,488.

During the late seventies, Castle Dome Mining and Smelting Company, with Wm. P. Blake as President, acquired control of all the important claims in the district and began shipping ore to its own smelter at Melrose, California. This company was the principal producer of the district during 1883.

Production from the district fell off sharply after 1883. According to the U.S. Mint Reports, 12 tons of 60 per cent lead ore, yielding $840 in silver, were produced in 1887.

During 1890-96, Gondalfo and Sanguinetti, of Yuma, shipped to the Selby Smelter 906 tons which yielded 1,000,000 pounds of lead and 25,000 ounces of silver, valued at $57,000.

During 1897-1904, production continued, but no adequate records of it are available.

Since the end of 1904, more or less complete production records have been given in the yearly Mineral Resources volumes and U.S. Minerals Yearbooks. Intermittent mining has been carried on by owners and lessees. Prior to 1942 most of the ore was hand sorted, but some was concentrated on dry tables.

During 1942-45, Arizona Lead Company mined dumps, store fills, and ore from the De Luce and Rialto claims. According to George Holmes, manager of the Company, this material, treated in a gravity concentrator of 100 to 150 tons daily capacity at the Gila River, west of McPhaul bridge, yielded more than 5,000,000 pounds of lead. For the year 1944 the district ranked seventh in Arizona lead production. During 1946-47, Joplin Lead Company operated this mill on ore principally from the Rialto claims.

**Fluorspar mining:** The first important mining of fluorspar, a plentiful gangue mineral in the Castle Dome ore, began in 1902.
PRODUCTION OF LEAD AND SILVER, CASTLE DOME DISTRICT*

<table>
<thead>
<tr>
<th>Years</th>
<th>Tons ore</th>
<th>Lead Pounds</th>
<th>Lead Value</th>
<th>Silver Ounces</th>
<th>Silver Value</th>
<th>Total Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1870-76</td>
<td>2,000</td>
<td>2,200,000</td>
<td>$88,000</td>
<td>100,000</td>
<td>$130,000</td>
<td>$218,000</td>
</tr>
<tr>
<td>1877-83</td>
<td>3,500</td>
<td>3,500,000</td>
<td>$140,000</td>
<td>105,000</td>
<td>$115,500</td>
<td>$255,500</td>
</tr>
<tr>
<td>1890-96</td>
<td>1,000</td>
<td>1,000,000</td>
<td>$38,000</td>
<td>26,000</td>
<td>$26,000</td>
<td>$64,000</td>
</tr>
<tr>
<td>1897-1905</td>
<td>2,000</td>
<td>1,300,000</td>
<td>$52,000</td>
<td>44,000</td>
<td>$28,600</td>
<td>$80,600</td>
</tr>
<tr>
<td>1906-41</td>
<td>26,871</td>
<td>4,171,537</td>
<td>$281,527</td>
<td>105,564</td>
<td>$73,322</td>
<td>$324,350</td>
</tr>
<tr>
<td>1942-49</td>
<td>74,693</td>
<td>5,555,400</td>
<td>$487,544</td>
<td>78,757</td>
<td>$59,077</td>
<td>$546,621</td>
</tr>
<tr>
<td>1870-1949</td>
<td>110,064</td>
<td>17,726,937</td>
<td>$1,057,071</td>
<td>459,321</td>
<td>$432,499</td>
<td>$1,489,571</td>
</tr>
</tbody>
</table>

During 1902-04, 1908-09, and 1913, selected material, derived mainly by hand sorting and screening, was shipped to Riverside, California, to be used as flux in producing cement clinker. The potash shortage of the World War I period encouraged the Riverside Company to develop a potash-recovery method, which utilized fluorspar, in cement manufacture. For this market, according to local reports, more than 1,000 tons of fluorspar were shipped from Castle Dome during 1916-18. The U.S. Mineral Resources, however, credit the district with a total output of only 1,152 tons, valued at $11,747, for the years 1902-17. Since 1918 the production has been intermittent and small.

**FLORA TEMPLE CLAIM**

The Flora Temple claim, owned for many years by the late Mrs. Eliza De Luce, was surveyed for patent in 1871 for Messrs. Polhamus and Gunther, and has the distinction of being the second claim patented in Arizona. As permitted by the mining laws of that time, it is 2,000 feet long by 200 feet wide.

The Flora Temple yielded 400 tons of ore in 1871 and for a long period was one of the most important producers in the district, but its total output is unknown.

The surface of this claim is mantled by surface gravel several feet thick. The principal vein strikes N. 18 degrees W. and dips 45 to 55 degrees E. Blake states that a vertical vein, striking a few degrees more northwesterly, branches from this vein near the southern boundary of the claim.

Workings on the Flora Temple are extensive. At least sixteen shafts, more or less connected by irregular, partially filled stopes, have been sunk at intervals along the length of the claim. A large portion of these workings are old and inaccessible. Blake shows the western vein in a vertical section more than 100 feet deep and states that its character is similar to that of the eastern vein.

The main Flora Temple shaft is 225 feet deep on an incline of 45 to 55 degrees E. From the surface it passes through some 25 feet of cemented gravels which in their lower portion contain numerous nuggets of lead minerals. Downward the footwall is mainly dense gray slate, and the hanging wall rhyolite porphyry. For a depth of approximately 190 feet on the incline, the vein has been stoped out for a width of 1 to 10 feet or an average of about 4½ feet and along a length of 100 to 160 feet.

Other stopes connected with the older shaft extend at intervals along the vein. Some of them were worked and abandoned prior to 1880.

The 200 level, (Fig. 24), where accessible in 1930, followed a well-defined fault that dips 55 to 60 degrees E. and is intersected by several northeast fissures. It appears to be the locus of the main vein. On this level, a narrow vein of galena with the usual gangue minerals was exposed for a length of a few feet north of the main shaft. At the northern end of the drift, a little iron oxide, but no ore, occurs adjacent to the fault. The vein is very
narrow to absent for some 30 feet south of the main shaft but widens somewhat in the diorite-porphyry area towards the old shaft.

During 1944 Arizona Lead Company ran some diamond drill holes from a shallow shaft 550 feet southwest of the Flora Temple to prospect for possible concealed veins, but the results were negative.

SENORA CLAIM

The Senora claim is about 1,500 feet south of the Flora Temple. It was located at an early date and has been one of the principal producers in the district. During recent years it has been worked intermittently.

According to the late Arthur Haack, the galena moved from this claim prior to 1930 averaged about 29 ounces in silver per ton.

Local geology: On the surface, narrow bands of steeply dipping dense gray shale alternate with dikes of diorite porphyry and rhyolite porphyry. The diorite porphyry predominates and southeast of the main shaft forms a mass more than 100 feet wide. Fully half of the Senora claim is covered by surface gravel which, in the vicinity of the vein, contains abundant nuggets of placer lead minerals.

The mine workings seen in 1930 were mainly in diorite porphyry about the 250 level and did not show much of the shale. Below that level they were in rhyolite porphyry.

Figure 24.—Flora Temple mine, plan of part of workings, main shaft and 200 level as of 1930.
Main vein: The Senora vein strikes N. 20 to 40 degrees W. and dips 50 to 70 degrees E. In the northern portion of the claim, it forks and traverses dense gray slate that shows some cherty bands. Here the vein has a gangue of gray blocky calcite crystals up to an inch in diameter, intermingled with smaller crystals of fluorite. This gangue contains masses of galena up to 2 inches in diameter and cubical pseudomorphs of black anglesite after galena. Both the galena and anglesite are coated with films of rusty-red lead oxide.

As shown in the mine workings, the vein follows a well-defined fault, the plane of which is wavy on a broad scale. As indicated by stopes, the width of the vein ranges from a few inches to 5 or more feet. Below the 250 level in the shaft, the vein is in rhyolite porphyry and becomes only a few inches thick.

The gangue of the vein consists mainly of pale green, purple, and rose-colored fluorite, in crystals from less than an inch up to several inches in diameter. Along with the fluorite occur crystalline calcite, bladed to massive barite, and minor amounts of fine-grained quartz. This barite is clearly later than the fluorite.

Galena occurs as irregular veins and masses within the gangue and is superficially altered to anglesite, cerussite, and oxides.

At places on the upper levels, hydrozincite occurs associated with gypsum, mainly in fissures that have become solution channels. These channels also contain other secondary minerals, notably calcite, quartz, lead and zinc carbonates, and wulfenite.

Other veins: On the 100 level, three other veins were found east of the main vein. They strike about N. 30 degrees W. and follow steeply eastward-dipping fault zones. Mineralogically they are similar to the main vein, and the easternmost one contains large lumps of galena, in places more than a foot thick.

These veins, as well as those on the Little Dome claim, may belong to the same general zone of fissuring as the Senora, but their relations to it are obscure.

Possibly the Senora fissure zone continues north-northwestward beneath the alluvium, but, if so, its position and mineral content there have not been ascertained.

Workings: Workings on the Senora claim in 1930 (Fig. 25) included three shafts in the south-central portion. The southernmost shafts, 250 and 300 feet deep on the dip of the vein, are approximately 75 feet apart and more or less connected by stopes. Down to the 200 level, the vein has been largely stoped out over a length of 100 to 250 feet and an average width of about 3 feet. Below the 200 level, stoping extended for a depth of 50 feet over a length of 125 to 150 feet, all south of the deeper shaft. Portions of these stopes were filled, particularly in the vicinity of the southernmost shaft. Mr. Haack stated that a test run on 1,000 pounds of screened material under 1 inch in diameter from this fill yielded 10 per cent lead.
Figure 25.—Senora mine, plan of principal workings as of 1930. M, manway; R, raise; dotted line, approximate outer limit of stoping; heavy lines indicate faults.
LITTLE DOME CLAIM

The Little Dome claim, adjoining the Senora on the northeast, was worked intermittently over a long period of years.

Steeply dipping dense gray shale occupies the northeastern portion of the claim, but the central portion shows mainly a large dike of diorite porphyry. Smaller dikes of rhyolite porphyry cut these two formations, and a thin veneer of surface gravels covers portions of the area.

The principal vein occurs along a fault zone that strikes N. 45 to 55 degrees W. and dips 85 degrees SW. The best ore in the vein was found where oblique cross fractures intersect this fault. Much of the vein is 2 or more feet wide but appears to fray out at the ends. It is made up of crystalline fluorite and calcite, cut by veinlets of crystalline to massive barite, and contains irregular masses and stringers of galena. More or less gouge is intermingled with the gangue. The galena shows considerable alteration to dark anglesite, white cerussite, and yellow oxides. According to the late Arthur Haack, this galena averages from 28 to 30 ounces of silver per ton, but the carbonates contain only from 4 to 6 ounces. Stopes from 4 to 7 feet wide have followed the vein for a length of approximately 125 feet and a depth of 20 to 60 feet. Part of the old stopes contain fill. Mr. Haack stated that 30 tons of this old fill yielded $1,700 when lead sold at 7 cents per pound.

A parallel vein, some 10 feet south of the main vein, had been explored for a few feet. It showed a maximum width of 2½ feet of crystalline fluorite but very little galena.

BIG DOME CLAIM

The visible rocks on the Big Dome claim consist of steeply westward-dipping shale cut by large dikes of diorite porphyry, as indicated on Figure 23. Workings on this claim include four old shafts and an adit in shale near the diorite porphyry contact. No recent information upon these workings is available, but Blake in 1880 stated that the shafts were from 180 to 225 feet deep, and that good ore had been extracted from stopes connecting the northernmost three shafts above the 200 level. As indicated by dumps, the vein contained abundant fluorite.

BUCKEYE VEIN

The Buckeye vein, immediately northeast of the Flora Temple, is traceable in a direction of S. 25 degrees E. more or less continuously for a length of 4,000 feet in the Castle Dome, New Dil, and Lady Edith claims (Fig. 23). On the New Dil and Lady Edith claims, it forks and passes under alluvium, but in the middle portion of the Yuma claim a limited outcrop shows a vein approximately in alignment with the New Dil and Big Dome veins. Presumably the Big Dome is on the same fissure or zone of fissuring as the New Dil.

This vein was worked before 1870 and yielded 850 tons of ore during 1871, but its total production is unknown.
As seen on the surface, the Buckeye vein prevailingly dips 70 degrees W. and ranges from a few inches to several feet wide. Mineralogically and texturally it is similar to the other veins of the district.

Castle Dome claim: The Castle Dome claim was surveyed for patent in 1876. It was a notable producer in 1870 but has been idle for many years. Its surface, 2,000 feet long by 200 feet wide, is mantled by gravel. The patent-survey plat of 1876 shows seven shafts, from 40 to 191 feet deep, in the southern half of this claim.

New Dil and Lady Edith claims: In the limited outcrops on the New Dil and Lady Edith, the vein occurs along or near the contact between diorite porphyry and shale. Near the northern end of the New Dil claim, the shaft dumps consist largely of rhyolite porphyry, which appears to have been an unfavorable host rock for mineralization. The ore shoots may be related to northeast fissures which intersect the vein at numerous places.

Workings on these claims, as of 1944, included some twenty-two shafts of which one, reported to be 600 feet deep on the incline, is 200 feet from the northern end of the New Dil, and another, 400 feet deep, is 950 farther south. Stoping above the 300 level extends more or less continuously throughout the length of the New Dil and for a length of approximately 100 feet south into the Lady Edith claim. Much of the work was done more than 70 years ago; prior to 1880, according to Blake, this ground, then known as the Hopkins and Norma claims, had been stope out continuously for a distance of 1,000 feet and to a depth of 200 to 250 feet.

HULL OR RIALTO CLAIMS

The Hull or Rialto claims are in the northwestern portion of the area mapped on Figure 23.

In 1880 Castle Dome Mining and Smelting Company shipped considerable ore from the Chief of Dome, Diana, and Soprise ground, then known as the Douglas, Railroad, and Pocahontas claims. According to the late Arthur Haack, a mill of 30 tons daily capacity was run during 1902 or 1903 with water from the 300 level of the Lola claim. Sam Ashe, manager of the Rialto Company in 1930, stated that a mill worked part of the dump during 1915. This mill was equipped with a crusher, rolls, plunger jigs, and two Wilfley tables.

Local geology: Most of the Hull claims are mantled by surface gravel, but cropping out through it are a few low hills of well-bedded dense gray shale, limestone, and sandstone, cut by dikes of diorite porphyry.

Vein and workings: The principal vein, which follows a fault zone in dense gray slate, strikes approximately N. 30 degrees W. and dips 65 to 75 degrees NE. Where exposed on the Diana and Soprise claims, the vein is traceable as a gray streak of weathered fluorite and calcite, together with local masses of partly oxidized galena. The wall rock reveals an intense development of sericite and less secondary quartz and chlorite.
Underground workings have explored the vein for a length of more than 2,000 feet. From northwest to southeast on the Chief of Dome and Diana claims, the principal shafts are as follows: Old mill shaft, 380 feet deep; present operating shaft, 300 feet deep; and five shafts on the Diana claim, with depths of 300, 470, 85, 60, and 45 feet. Between these shafts, the richer portions of the vein have been largely stoped out. Some of these workings are very old, and those earlier than 1880 on the Diana and Soprise (then the Railroad and Pocahontas) were described by Blake as follows: "On the Railroad claim, which has furnished a large amount of ore, extraction has been above a depth of 165 feet. The Railroad vein near the main shaft is 12 feet thick and well filled with ore. The ore ground appears to be strongest towards the north end and to plunge downwards there to a greater depth." The wash gravel at this point is relatively deep.

The 265 level of the present vertical operating shaft shows the vein to have been stoped for a distance of more than 400 feet southeastward. This stope, which in places has a width of 18 feet, was not accessible in 1930 but was said to extend in places to the water level, which then was at a depth of 225 to 275 feet. Exposed, unmined portions of the vein contains masses of partly oxidized galena in a fluorite-calcite gangue. Northwestward, towards the old mill shaft, the vein for about 100 feet carries only small bunches of ore along fractures, but an intersecting, nearly vertical fault marked by gouge 4 feet thick, contains a galena-bearing streak 2 feet wide.

Northward from a point approximately 175 feet north of the old mill shaft, the vein widens and contains chunks of galena, as much as 50 pounds in weight, within a gangue of crushed fluorite and calcite. As of 1930, the 380 level of the old Mill shaft extended for some distance northwestward on a barren, wet fracture zone.

Immediately south of the road, a vertical shaft 470 feet deep connects at a depth of 135 feet with the top of the old stope already mentioned. Within open cavities of the vein here, a little wulfenite appears. Blake stated that considerable amounts of vanadinite and a vanadiferous mimetite were found associated with wulfenite on the Railroad (Diana) claim.

In May, 1930, water was being removed from the workings by a Cameron air pump. According to Mr. Asche, the water then raised amounted to 6,000 or 7,000 gallons each twenty-four hours, but in certain seasons had reached a total of more than three times that amount. Subsequently the water level receded, and in 1945 it was below the principal workings.

CLEVELAND-CHICAGO VEIN

The Cleveland-Chicago vein, 3,600 feet east of the Flora Temple, was located many years ago. In the early days it was worked by Pete Hodge, and prior to 1913 at different times by Messrs. De Luce, Haack, and Timmons.
In this vicinity, well-bedded, steeply southwestward-dipping metamorphosed shale and impure limestone are intruded by several dikes of diorite porphyry and rhyolite porphyry. Surface gravels mantle part of the Cleveland claim.

The vein is traceable for approximately 1,400 feet along a fissure that strikes N. 30 degrees W. and dips about 80 degrees W. At the northwestern end it occurs in shale with a dike of rhyolite porphyry near the footwall, but farther southeast it cuts or lies near a dike of diorite porphyry. As seen at the surface, this vein has a maximum width of 3 feet, but most of it is narrower. The principal gangue consists of clear, crystalline calcite, together with fluorite and less barite. According to Mr. Haack, the galena content was rich.

Workings on this vein include two shafts 170 and 130 feet deep on the Cleveland claim, a shaft 100 feet deep on the Chicago claim, and several shallower holes. A considerable portion of the vein above the 100 level appears to have been stoped. When visited in 1930, the surface equipment had long been dismantled.

ADAMS CLAIMS

The Adams claims are south of the Chicago, in the southeastern portion of the area mapped on Figure 23. During 1918-30 about 125 tons of galena ore were shipped from this ground.

Here the shale is cut by dikes of diorite porphyry and a few small masses of rhyolite porphyry. Much of the area is covered by surface gravels.

Workings on these claims in 1930 included four shafts, each about 200 feet deep. The principal shaft, on the Puzzler claim, struck water at a vertical depth of approximately 192 feet. On the 55 level of this shaft, some 100 feet of drift shows the vein to occupy a fault zone that strikes N. 23 degrees W., dips 70 degrees NE., and in places is 7 or 8 feet wide. The vein material consists of fluorite, brownish-black calcite, and galena in reddish-brown gouge and brecciated slate. Vanadinite and wulfenite occur locally in vugs. On the 110 and 175 levels, respectively, about 230 and 290 feet of drifts show the vein to be much the same as on the 55 level. In general the best ore occurs where the fault zone contains the reddish gouge.

Comparatively little drifting has been done from the other shafts on these claims. One of them is reported to have yielded, at 70 feet, a chunk of galena 18 inches long, 16 inches wide, and 2 to 4 inches thick.

MABEL CLAIMS

The Mabel group of claims is in the hilly country between the Chicago and the Adams claims.

Part of this ground, formerly known as the Puckett property, has been worked intermittently since the early days and has produced notable amounts of galena ore. At times the ore was treated in a small concentrator.
Here the shales strike northwestward, dip 50 degrees SW., and are intruded by dikes of diorite porphyry and rhyolite porphyry. Surface gravels mantle part of the area.

The following information was furnished in 1930 by W. E. Smith, who then was in charge of the property: The workings included the Mabel shaft, 324 feet deep, and four shafts 380, 60, 50, and 49 feet deep. Water stood in the Mabel shaft at a depth of 314 feet. Most of the stoping had been south of this shaft, on a streak of galena 11 inches thick that feathered out in depth.

LINCOLN OR COLORADO CLAIMS

Several claims, formerly known as the Colorado group and held in 1930 by E. Lincoln, extend southward from the Union shaft. Subsequent to 1900, they were held by A. P. Modesti and produced argentiferous galena valued at several thousand dollars. Part of this ground is covered by surface gravels, but the rock and vein outcrops visible are similar to those of the northern portion of the district. Some of the veins are marked by copper stain. The wall rocks show strong silicification and sericitization.

The surface equipment of these mines had been dismantled prior to 1930.

ANNIE MINE

The Annie mine, in the Middle Mountains, midway between the Colorado River and the Castle Dome Range, is considered in statistical reports as part of the Castle Dome district.

According to the U.S. Mineral Resources, some ore was shipped from this mine in 1924 and 1926.

Here, a diorite-porphyry dike approximately 150 feet wide intrudes shale, trends south-southwest, and near its eastern margin is cut by a steeply northwestward-dipping fault zone that strikes S. 15 degrees W. This zone, which is silicified for a width of 2 or 3 feet, contains irregular bunches of limonite, a few small spots and thin streaks of malachite, and a thin, bunched vein of galena in a baritic gangue. The wall rock shows pronounced sericitization. As exposed by a tunnel about 300 feet long, this galena vein ranges from a fraction of an inch up to 6 inches in thickness.

REFERENCES, CASTLE DOME DISTRICT

INDEX

Abril mine, 23
Adams claims, 113
Alberding, H., 52
Alexis, Carl O., 36, 37, 39, 53, 54
Annie Marie property, 40
Annie mine, 114
Arizona Lead Co., 104
Armistice mine, 40
Ashe, Sam, 111

Banner district, 66
Bargain Mines, Inc., 23
Big Dome claim, 110
Billingsley Machinery Co., 20
Black Rock mine, 93
Blake, Wm. P., 103, 106, 110, 112
Blue Bird mine, 63
Bluebird Mines, Inc., 57
Blue Bird Silver Mining Co., 57
Boericke Co., 90
Borderland Metals property, 40
Breccia pipes, 61, 62
Buckeye vein, 110
Bunker Hill district, 56
Bunker Hill mine, 57

Callahan Zinc-Lead Co., Inc., 73
Calumet and Arizona Mining Co., 53, 56
Castle Dome claim, 111
Castle Dome district (Yuma County), 98
Cave mine, 40
Chance mine, 34
Chicago claim, 112
Chief mine, 55
Chief of Dome claim, 111
Chilito, 82
Choctaw mine, 42
Cleveland claim, 112
Clip, 86, 87
Colorado claim, 114
Continental Commission Co., 72
Copper Creek, 56
Copper State Metals Mining Co., 57
Courtland, 13
Cumberland mine, 57
Curtin mine, 82

Defiance mine, 19
De Luce, Mrs. Eliza, 106
Diana claim, 111
Districts, 8, 9
Douglas claim, 111
Dragoon Mountains, 10
Dragoon workings, 19
Dripping Spring Mountains, 66, 67

Eagle-Picher Mining and Smelting Co., 42
Empire district, 49
Escapule mine, 28
Eureka district, 83, 89

Feiss, J. W., 54, 55
Fields Mining Corp., 57
Flora Temple claim, 106
49 mine, 55
INDEX — Continued

Fowler, George M., 43, 46

Galbraith, F. W., 30, 50
Galuro Mountains, 56
Gilluly, Jas., 12
Gleeson, 13
Golden Rule mine, 28
Goldfield Cons. Mines Exploration Co., 41
Gopher mine, 55
Gordon, Jonathan, 20
Gordon mine, 20

Haack, A., 107, 110, 113
Hamburg, H., 37
Hartford district, 37
Hershey, O. H., 93
Hess, F. L., 52
Hilton area mines, 53
Hilton, E. P., 54
Holmes, George, 83, 90, 93, 96, 104
Horn Gold claim, 42
Huachuca Mountains, 36
Huachuca Queen Mining Co., 39
Hubbard mine, 29
Hull or Rialto claims, 111
Humphrey mine, 82
Humphrey, T. Z., 82

Jackson mine, 28
Jackson, Mrs. E. M., 28
James mine, 37, 40
Joplin Lead Co., 104

Keystone Gulch area, 81
Kiersch, George A., 66, 67, 81
Kuhn, Truman H., 56

Lady Edith claim, 110, 111
Larson, E., 33
Last Chance or 1907 mine, 20
Lead Mountain area, 53
Lincoln or Colorado claims, 114
Little Dome claim, 110
Lomelino Mineral Development Co., 21
London-Arizona mine, 66, 82
Loofbourrow, R. W., 42
Loring, W. B., 30
Lucky Shot mine, 42

Mabel claims, 113
Mandan claim, 94
Manila mine, 39
Manzoro Gold Mining Co., 28
Mayuga, M. N., 54
Mendevil claims, 97
Middle Mountains, 114
Miller, Hugo, 42
Mitchell Development Co., 38
Modesti, A. P., 114
Montana mine, 43
Moore, R. T., 87
Morgan, Robt., 93
Morris, D. F., 20
Mountain Queen or Scribner mine, 33
INDEX — Continued

Muheim mine, 28
Mystery mine, 17

Neal Mining Co., 90
New Dil claim, 110, 111

Old Terrible mine, 28
Operations, Inc., 20
Oro Blanco or Ruby district, 41
Owens, Sherwood, 23

Pacific claim, 94
Panama or Manila mine, 39
Papago mine, 96
Penn Metals, Inc., 90
Pocahontas claim, 111
Primos Co., 90
Prince mine, 54, 55
Production summary, 7
Puckett property, 113

Railroad claim, 111
Reagan Camp prospects, 81
Red Bird mine, 57
Red Cloud Cons. Mines Co., 90
Red Cloud mine, 90
Red Cloud Mining and Milling Co., 83, 90, 96
Rialto claims, 111
Riho vein, 96
Riley, Walter, 83, 90, 93, 96
Riverview claims, 97
Roseveare, G. H., 83
Ruby district, 41

San Juan or Gordon mine, 20
Schrader, F. C., 52, 53
Scribner mine, 33
Senecia mine, 26
Senora claim, 107
Seventy-Nine Lead-Copper Co., 73, 81
Seventy-Nine mine, 66, 72
Shattuck Denn Mining Corp., 23, 67, 73, 81
Silent, 87
Silver Bill mine, 15
Silver District, 63, 87
Smith, W. E., 114
Soprise claim, 111
Sparkes, Miss Grace, 38
State of Texas mine, 38
Sunnyside, 37
Swisshelm district, 30
Swisshelm Mountain Gold and Silver Mining Co., 35

Tom Scott mine, 14
Total Wreck mine, 52
Trigo Mountains, 84
Turquoise district, 13
Twin-S mine, 57

Warren, H. V., 42
Weber, Robert H., 36, 37
White, L. C., 83, 96
Wulfenite production, Total Wreck mine, 52

Zeckendorf, L., 41