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Article 152

QUATERNARY MUDFLOW DEPOSITS NEAR SANTIAGO, CHILE

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Abstract.—Mudflows appear to have played an important role in the accumulation of nonsorted, nonstratified Quaternary valley fill in central Chile. Much of the mudflow material in the vicinity of Santiago is pumiceous. A widely accepted hypothesis of glacial origin for these deposits is rejected.

Santiago, the capital city of Chile, is in a tectonic depression or graben that forms the Valle Central of Chile (fig. 152.1). The depression is partly filled with unconsolidated sediments of Quaternary age.

Large volumes of nonsorted and virtually nonstratified valley-fill sediments at or near Los Cerrillos, Pudahuel, Cerro Apoquindo, and Puente Alto (fig. 152.2), have been described by various workers as moraines (Brüggen, 1950; Karzulovic, 1958; Muñoz Cristi, 1960). Brief observations by R. F. Flint in April 1959 of some of the deposits, particularly of those containing large volumes of pumiceous ash, cast considerable doubt on a glacial origin. Later and more detailed examination by the authors confirms the nonglacial origin of these deposits, which are now believed to result from mudflow deposition and creep. The general term "diamicton" is applicable to at least some of these nonsorted noncalcareous terrigenous deposits composed of sand and larger particles in a matrix of mud (Flint and others, 1960a, b).

The Valle Central near Santiago is filled to a depth of more than 400 meters with sedimentary materials eroded from the surrounding highlands and transported by running water, mudflows, or as slides. Most of the materials are derived from the Cordillera de los Andes to the east; lesser amounts have been eroded from the Cordillera de la Costa to the west. The bedrock in both ranges is mainly igneous, including both volcanic and intrusive types, and is predominantly of Mesozoic age.

The oldest valley-fill sediments known in the area are lacustrine silt, clay, and sand at a depth of as much as 250 m in study well 1, near Pudahuel, and 236 m in well E3–26, in Santiago (fig. 152.2). The age of these sediments is unknown, although in well 1, small freshwater gastropods were found in microlaminated clay at a depth of 157 m.

The fine-grained lacustine sediments of the valley are overlain by coarse-grained fluvial materials which in well E3–26 extend to a depth of 150 m below the surface. Alluvial-fan deposits of the Ríos Lampa, Colina, Mapocho, and Maipo make up the bulk of these materials. Gravels are exposed in terraces along the Río Maipo and in gravel pits around the fringes of Santiago. Colluvium resulting from sheet erosion occurs in narrow zones bordering the valley, particularly north and west of Santiago. Knowledge of the origin and character of the valley fill is especially important in problems of ground-water supply, which are discussed in Article 169.

Diamicton deposits overlie altered bedrock along the mountain front east of Santiago and interfinger with alluvium in the basin. Pumiceous deposits, which contain large blocks of andesite and granodiorite and cover the fluvial and lacustrine deposits west of Santiago, appear to be of similar origin. Other pumiceous deposits

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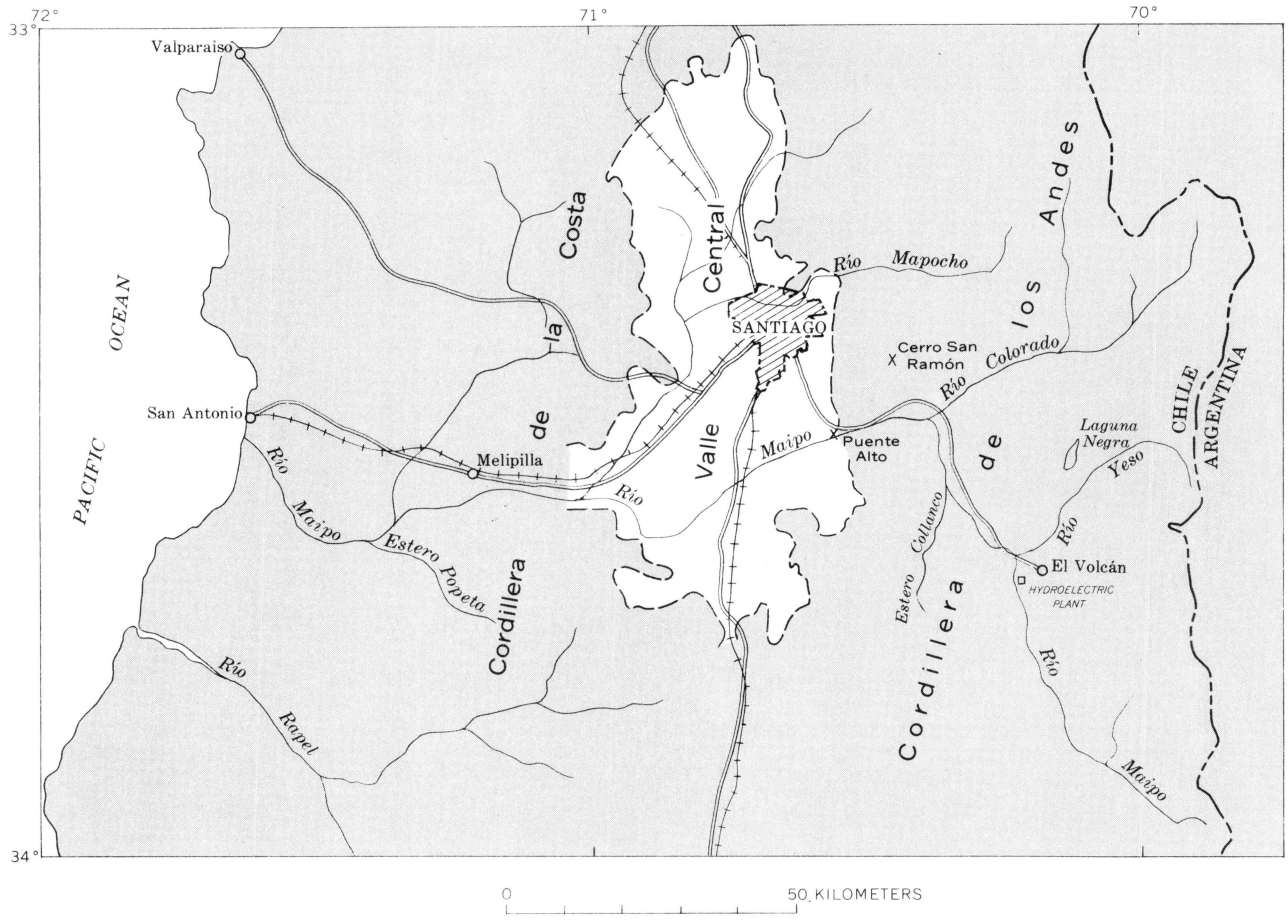

FIGURE 152.1.—Index map of part of central Chile. Quaternary valley-fill deposits outlined by dashed line.

which do not contain large blocks of other rock, found in the valley of Estero Papeta and in the basin of the Río Rapel, southwest of Santiago (fig. 152.1), appear to be lacustrine (Brüggen, 1950, p. 221).

Within the area of figure 152.1, unquestioned till is limited to the high Cordillera de los Andes. Moraines are found at minimum altitudes of 1,600 m in one or two valleys (that of the Río Colorado, for example), but most till and all glacial cirques occur above 2,000 m at lat 33°–34° S. The best exposed and most accessible moraine in the region extends 12 km along the Río Yeso, between 1,670 and 2,700 m above sea level, and terminates on the south side of Laguna Negra (fig. 152.1). The till of this moraine has a matrix of gray unweathered rock flour. The included blocks are angular and are of two lithologic types, granodiorite and andesite. The granodiorite blocks are as much as 4 m across; those of andesite are as much as 1 m or a little more. Through much of the moraine the two kinds of boulders are segregated into alternate bands subparallel to the valley trend. The bands are boulder trains derived directly from intrusive and volcanic bedrock farther up the valley.

DIAMICTON DEPOSITS

The diamicton deposits of the region are of two types: one contains little or no pumice, and the other contains abundant pumice.

Diamicton deposits of the first type form a hummocky topography along the foot of the steep Andean front at the east edge of the Valle Central between the Río Mapocho and the Río Maipo (fig. 152.2), in a belt 800 m to 4 km wide. An outstanding feature of this belt is a row of hills that extends 5 km from Loma de los Baños northwest to Cerro Calán. The material that makes up the hillocks is well exposed in a cut between Loma de los Baños and Cerro Apoquindo, where angular to subrounded blocks of granodiorite and andesite as much as 2 m or 3 m in diameter are found in a matrix of weathered clasts ranging from clay size to coarse gravel. Here and in other parts of the deposit are scattered lenses, 1 to 2 m thick and as much as 10 or 15 m long, of pumiceous ash and sand or gravel, generally consisting of subangular grains. A gravel lens on Cerro Calán contains rounded cobbles. Deposits resembling those exposed in the cut between Loma de los Baños and Cerro Apoquindo crop out on the south

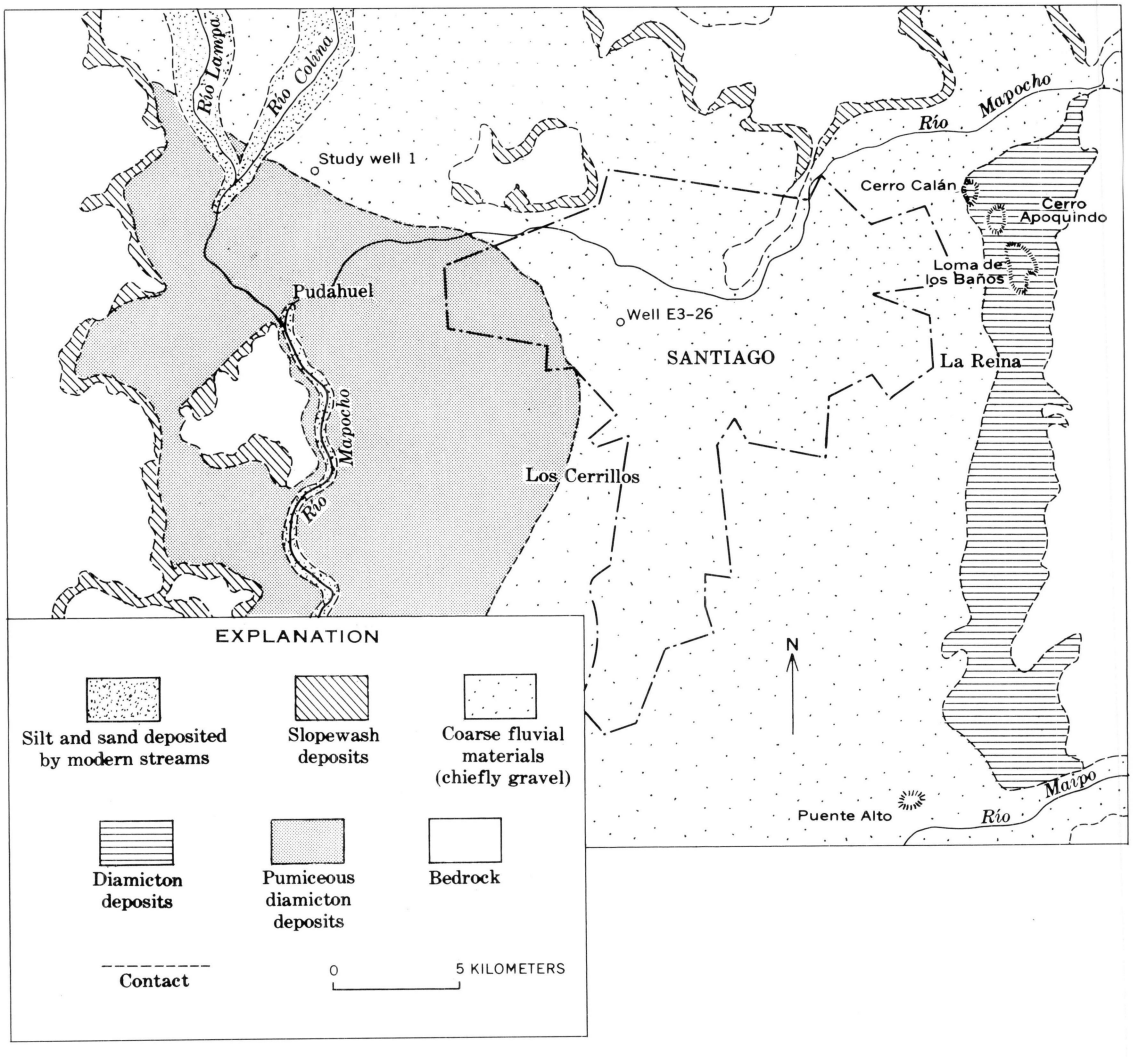

FIGURE 152.2.—Map of surficial deposits in the vicinity of Santiago.

side of the Río. Mapocho and between Loma de los Baños and the Río Maipo. All these deposits are more than 30 m thick, and at Cerro Calán they are approximately 100 m thick. They overlie deeply weathered rock to the east and interfinger with fluvial deposits from the Cordillera de los Andes toward the west.

East of Puente Alto, immediately north of where the Rió Maipo emerges from the Cordillera de los Andes, is an enormous fan-shaped diamicton deposit that extends downward and outward from an amphitheater-shaped hollow in the mountain front to the northeast. Angular blocks of granodiorite within and on top of the mass are so large and numerous that some of the diamicton deposits are easily confused with bedrock. Near the foot of the deposit a small lens of pumiceous sand is exposed in a highway cut 2 km north of the junction of the Santiago–El Volcán highway with the road to Puente Alto.

The most extensive deposit of the pumiceous diamicton forms a hummocky surface in the lowest part of the valley (Pudahuel–Los Cerrillos), immediately west of the city of Santiago at 450 to 485 m above sea level (fig. 152.2). It is exposed to depths of 10 m or less in a dozen or more large quarries, and study of drill cuttings indicates that the deposit extends to depths of as much as 30 m. The material consists of white or grayish fragments of pumice, predominantly of sand size, but including also silt and gravel. The deposits are poorly sorted and without stratification. Irregularly distributed subangular to subrounded blocks of andesite and granodiorite as large as 80 cm in diameter, some of which are highly decomposed, make up, on an average, about 20 percent of the total volume.

Other pumiceous diamicton sediments crop out on the south side of the valley of the Río Yeso, along the Estero Collanco near its junction with the Río Maipo and in the Melipilla area (fig. 152.1). On the summit and north flank of a ridge between the Río Yeso and El Volcán, there are small bodies of sand, locally pumiceous and containing scoriaceous fragments as much as 20

cm long. These deposits fill small depressions and form scattered patches on slopes 300 m to 450 m above the valley floor. Pumiceous float is found in colluvial deposits that consist chiefly of andesitic materials as much as 650 m above the valley. In a stream terrace 30 m above the lower course of the Estero Collanco a diamicton deposit is exposed that contains angular to subangular blocks as large as 2 m across in a light-gray ashy, partly pumiceous matrix. The blocks are of varied composition and are decomposed.

The western slope of the Andes is very steep, dropping from 3,200 to 700 m above sea level in a horizontal distance of 12 km, just east of Santiago. Because of the great relief, mass movement of materials evidently has been a very active process along the Andean front and in the high Andes during Pleistocene and Recent time. A contributing factor is the semiarid climate, which has inhibited the growth of protective forest on the slopes.

Mudflows are a common phenomenon on the western slopes of the Andes under present climatic conditions. Many mudflows were produced on the upper Río Maipo by an exceptionally heavy rainstorm on April 18, 1959. The canal that supplied a hydroelectric plant (fig. 152.1) was destroyed in several places, and the river upstream was dammed by a mudflow that descended a valley south of that of the Río Yeso and formed an unsorted deposit 10 km long and as much as 100 m thick. The resulting diamicton deposit, which contains blocks as large as 2 or 3 m in diameter (Pierre St. Amand, written communication, February 1963), closely resembles the diamictons of the Loma de los Baños–Cerro Calán area in lithology and thickness.

Mass movement presumably produced the great tongue-shaped deposits, later modified by erosion, that extend from Loma de los Baños to Cerro Calán. Other deposits are fan shaped, like the deposit east of Puente Alto. The practically continuous belt of diamicton deposits along the Andean front between the mouths of the canyons of the Ríos Mapocho and Maipo (fig. 152.2) evidently formed by the coalescing of many mudflows.

All degrees of transition between soupy mudflows and other types of mass movement can be recognized in central Chile, depending on steepness of the slope and proportion of water in the total mass as shown in the accompanying table.

The authors agree with Borde (1955) that the pumice immediately west of Santiago was deposited as mudflows. Explosive eruptions of pumiceous ash are known to have taken place in Recent time in the Cordillera de los Andes. Heavy rains presumably washed the easily erodible ash down the slopes and into the valleys,

Types of mass movement in the vicinity of Santiago

[Classification after Sharpe, 1938]

Movement		Earth or rock, dry or with minor amounts of water	Earth or rock, with water	Chiefly water
Type	Rate			
Flow	Usually imperceptible	Creep		Fluvial transportation
	Perceptible to rapid		Mudflow	
Slip (landslide)		Debris avalanche		

carrying cobbles and boulders of the pre-existing colluvium with it. Lubricated by abundant water, some of the pumiceous mixture evidently flowed out across the Santiago basin, lost monentum, and stopped in the flat lowlands of the western part. Boulders were dropped enroute because of deceleration of the mudflow, but some of the blocks were carried to the terminus of the flow.

The present authors reject the supposed glacial origin of the relatively unsorted deposits of the Valle Central near Santiago for the following reasons:

1. Similar diamicton deposits have been formed by mudflows in modern times in the same general area.
2. The bedrock underlying the deposits is deeply weathered; mountain glaciers scour deeply and their till commonly rests on fresh rock.
3. The fine matrix of the diamicton sediments is yellowish brown due to limonitization; nowhere is it gray and unweathered like the rock flour of the known glacial deposits of the Río Yeso moraine. The coarse material of the diamicton sediments shows no evidence of glacial transport.
4. Neither U-shaped valleys nor cirques, which characterize glacial sculpture, occur in or near the Santiago area.
5. At the latitude of Santiago, glacial moraines can be traced only as far downslope as 1,600 m above sea level, more than 1,000 m higher than the valley floor at Santiago.

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