Advancing the Utility of the British Columbia Regional Geochemical Survey Database Using Indicator Minerals Derived from a Regional Bulk Stream-Sediment Survey, Boundary District, South-Central British Columbia (NTS 082E)

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Introduction

Government-funded, reconnaissance-scale regional geochemical surveys (RGS) have been routinely conducted in British Columbia (BC) since 1976 (McCurdy et al., 2014). During this time, silt-sediment samples have been collected from more than 55 000 sites distributed throughout the province. The BC Geological Survey, the Geological Survey of Canada and Geoscience BC continue to support the development of the RGS database. New field surveys have been conducted and most available archived materials have been included in sample-reanalysis initiatives. The resulting RGS database has evolved into a comprehensive collection of field information plus accompanying multi-element analytical data. It continues to be recognized as an important resource for supporting mineral-exploration activities.

Although RGS coverage is extensive and the resulting database has great utility, there remain opportunities to collect samples in regions not previously surveyed and, more notably, in areas that have a limited number of existing sample sites. In many of these areas, deficiencies exist due to survey parameters established by the Geological Survey of Canada (GSC) that specified average densities to be one sample site every 13 km^2 (Friske and Hornbrook, 1991). The targeting of first- and second-order drainages at this scale has resulted in the partial coverage of some previously surveyed areas. In addition, using conventional silt sampling at the outlets of larger drainage basins potentially misrepresents the geochemical information generated due to the influence of sediment dilution and greater lithological variations within the stream catchment (Fletcher, 1997; Heberlein, 2013).

To examine how to resolve these gaps in the RGS database, a modified RGS sampling strategy that integrates the collection of bulk stream-sediment samples and derived mineralogical information, plus trace-metal data, has been included as part of a new regional stream-sediment survey conducted in the Boundary District in south-central BC (Figure 1).

Project Objectives

Indicator minerals derived from bulk sediments collected at the outlets of large drainage basins can effectively detect potential mineral deposits at far greater distances upstream than conventional silt sampling (McClenaghan, 2005). Extending the length of detectable mineral-dispersion trains enables the use of significantly fewer, strategically located bulk-sediment sample sites. Processing bulk-sediment material captures gold and sulphide mineral grains, plus potential oxide- and silicate-mineral indicators. Interpreting the abundance of these mineral grains and their morphological characteristics provides information about potential economic mineralization associated with precious- and base-metal deposit types that may exist upstream from a sample site in a drainage basin.

Collecting bulk sediments at a density of one site per 100 km^2 is routinely used as part of the Geological Survey of Canada's (GSC) current National Geochemical Reconnaissance (NGR) program and has been successful in detecting a variety of ore-deposit types (McCurdy et al., 2014). In BC, indicator-mineral methods are included as part of regional till surveys (Jackaman and Sacco, 2014) but are not yet fully integrated into regional stream-sediment programs.

Conducting a bulk-sediment sampling program in an area that was previously covered by a government-funded RGS program will demonstrate that this method can improve existing geochemical coverage; can add valuable mineralogical information to the existing RGS database; can enable relatively larger areas to be effectively assessed for mineral deposits; and is complementary to other exploration initiatives. In addition, this survey strategy targets considerably fewer sample sites, allowing for significant cost savings when compared to conventional infill methods that require

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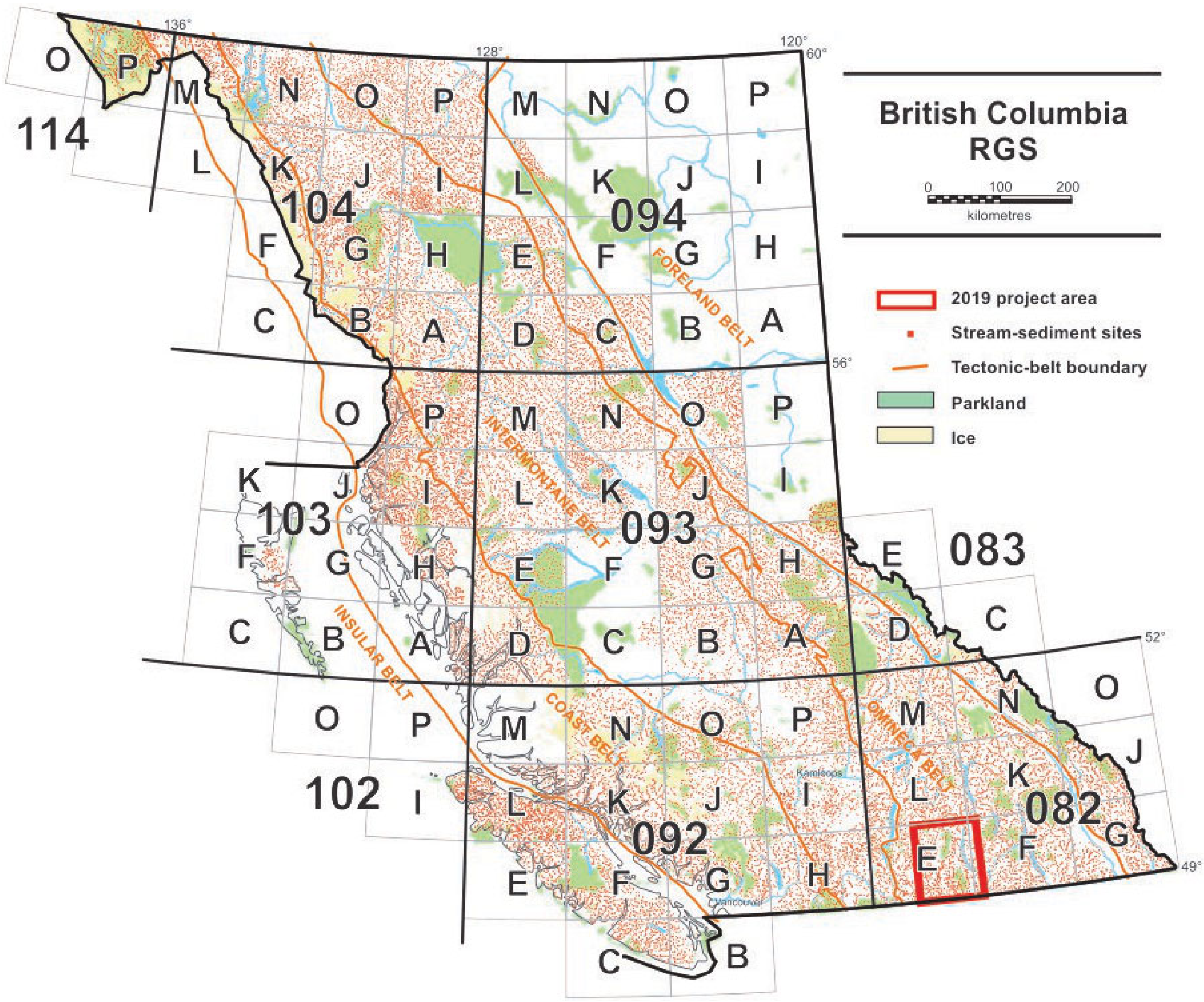

Figure 1. Location of the study area in the Boundary District, south-central BC.

greater sample-site densities and, more commonly, helicopter support.

Project Location

The project area is focused on the east half of NTS area 082E and covers approximately 10 000 km^2 (Figure 2). It is in the Columbia Mountain physiographic region. The west edge of the survey area includes part of the Okanagan Highland and extends east through the Monashee Mountains, past Lower Arrow Lake and into the Selkirk Mountains (Holland, 1976). Mountain peaks up to 2000 m in elevation are common and are drained by the Kettle and Granby rivers.

This region was targeted for this study for a number of reasons: 1) historical Au and Ag (plus Cu, Pb and Zn) mining camps hosted within a prospective geological setting continue to support an active exploration community; 2) other locally focused geoscience initiatives are ongoing, including an extensive geological mapping and mineral-evaluation program (Höy, 2019) funded by Geoscience BC; 3) the area offers ample opportunities to access sites using a well-developed highway and forest-service-road infrastructure; 4) the mountainous terrain that contains abundant, well-defined stream drainages suitable for regional geochemical stream-sediment surveys is typical of many areas in BC; and 5) a previous government-funded RGS program was completed in the area in the mid-1970s.

Previous RGS Programs

In 1976, reconnaissance-scale stream-sediment and water regional geochemical surveys were conducted by the GSC (Matysek et al., 1991). Within the study area, more than 1000 conventional silt-sediment samples were collected at an average sample-site density of approximately one site every 8 km^2. First- and second-order drainages would generally have been targeted, although many larger drainages (>10 km^2) would also have been sampled. These samples

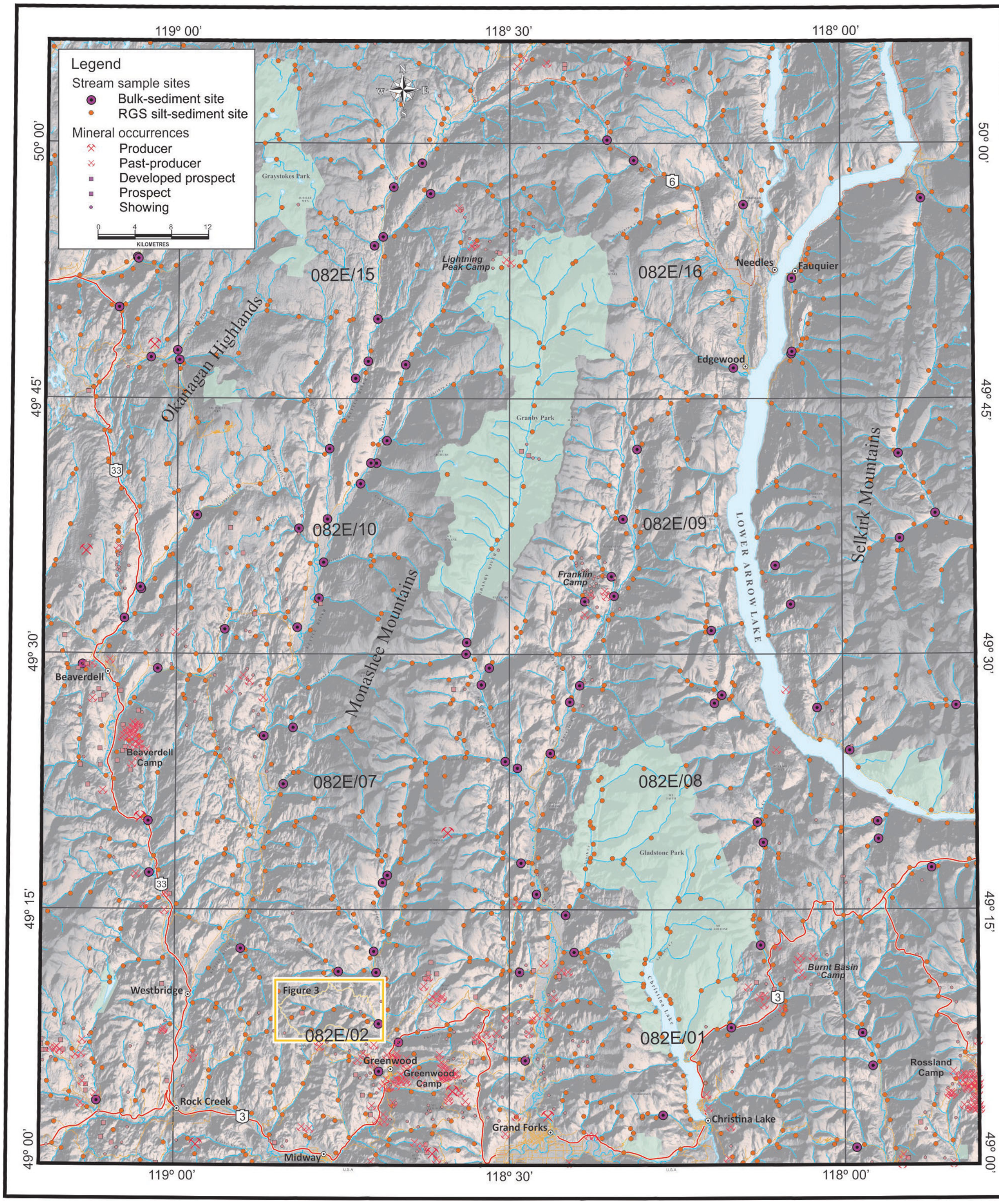

Figure 2. Distribution of MINFILE occurrences, previous RGS silt-sediment sample sites and new bulk-sediment sites in the study area, Boundary District, south-central BC. Digital elevation model from Natural Resources Canada (2015).

weighed from 1 to 2 kg and consisted of recently deposited, fine-grained sediments collected within the active stream channel.

Using the Wallace Creek drainage basin as an example, Figure 3 illustrates a typical distribution of silt-sediment samples collected during the 1976 RGS program. As part of the current study, a single bulk-sediment sample was collected at the main stem outlet. Six of the sites are at the outlets of small first- or second-order tributaries that have an average basin area of 2.5 km^2, and three sites located on the main stem of Wallace Creek drain areas of 20, 31 and 38 km^2. Coordinates for the RGS sites were acquired from Han and Rukhlov (2017). Originally digitized from 1:250 000 scale maps, location information collected during early RGS programs is inaccurate when mapped at a greater scale and results in sites being detached from the intended stream channel. To correct this situation, site locations were moved to the closest stream channel. The PEN Zn-Ag-Pb-Cu prospect (NTS 082E/02; MINFILE 082ESE118; BC Geological Survey, 2019) and CM Cu showing (NTS 082E/02; MINFILE 082ESE196) are located in the drainage, and underlying geology is from Höy (2019).

Sample pulps from these surveys were saved and stored at the GSC facilities in Ottawa. Starting in 1990, the samples were recovered from storage and reanalyzed by instrumental neutron activation analysis (INAA; Jackaman et al., 1991). In 2009, Geoscience BC funded the reanalysis of these pulps by inductively coupled plasma–mass spectrometry (ICP-MS; Jackaman, 2010).

Project Methods

Sample collection, sample processing and analytical methods are based on protocols developed by the GSC's NGR program. Accredited laboratories with previous experience of NGR requirements have been selected for sample preparation and analysis. These guidelines ensure that portions of collected materials can be incorporated into existing GSC and BC Geological Survey (BCGS) archives, and survey results can be included as part of the provincial and national geochemical databases.

During the late summer of 2019, 98 bulk sediment samples, 104 conventional silt samples and 98 pebble samples were collected at 98 stream sites draining areas that averaged 35 km^2. The smallest drainage sampled was 15 km^2 and the largest was more than 80 km^2. The average stream-channel width was 8 m and channel-bed composition ranged from gravels to cobbles in the larger valleys, with boulders in steeper drainages at higher elevations. Although efforts

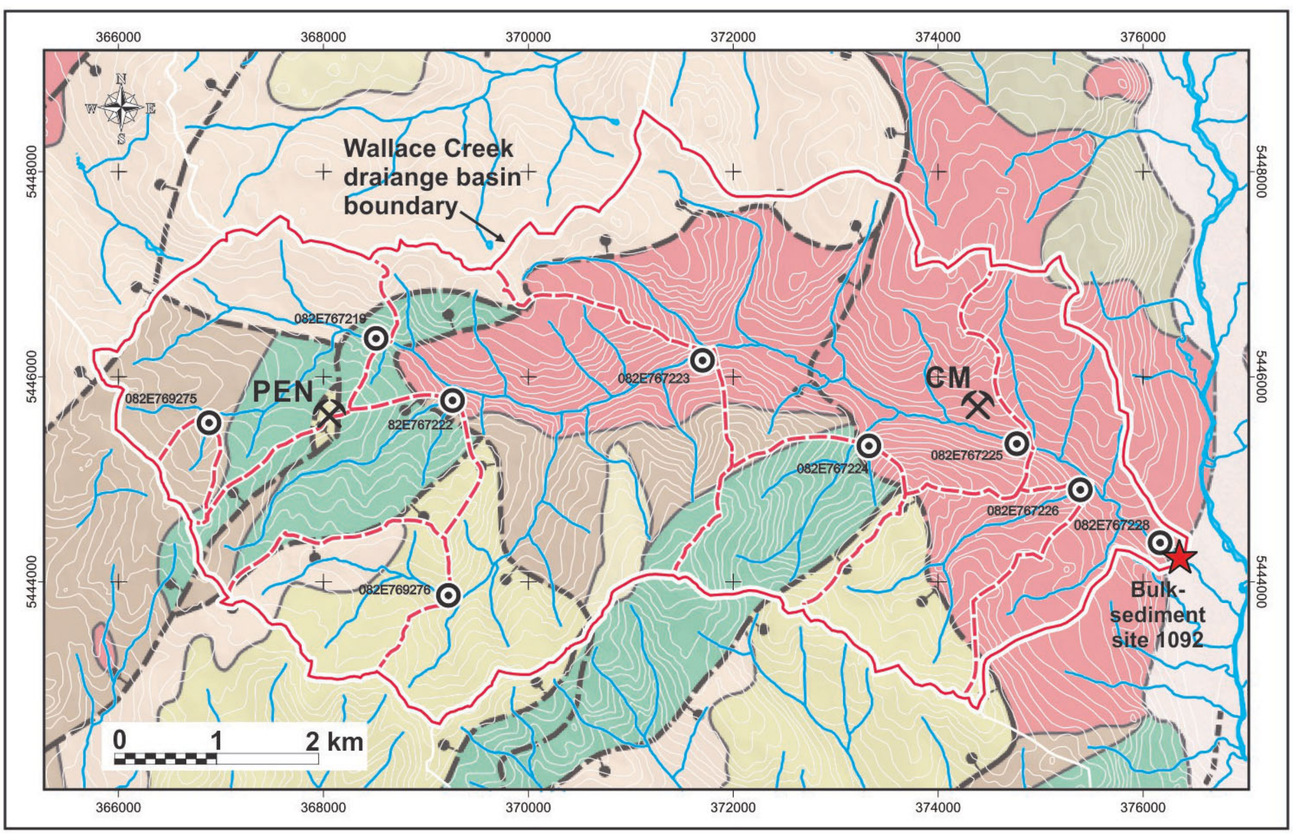

Figure 3. Typical distribution of the previous RGS silt-sediment sample sites and their relationship to a bulk-sediment sample collected at the main stem outlet of Wallace Creek. Mineralization: PEN Zn-Ag-Pb-Cu prospect, CM Cu showing.

were made to collect samples from predetermined sites, restrictions related to road quality and access to private land resulted in the collection of some samples from alternate locations.

At each site, a 12–15 kg bulk sample of sediment was collected from a single 50–75 cm deep, hand-dug pit located at the upstream end of mid-channel or side-channel bars or from mid-channel boulder traps (Figure 4). The material was obtained by wet-sieving coarse-grained sands and gravel using a US Sieve Series 10-mesh (2 mm) sieve and capturing the less than 10 mesh size grains in a 20 litre plastic pail lined with a polyethylene sample bag. Conventional silt samples were also collected from the active stream channel. An approximately 2 kg sample of fine-grained material was recovered and placed in a synthetic cloth bag. In addition, 50 large pebbles acquired from the oversized material during the sieving process were placed in a synthetic cloth bag. Standard field observations, photographs and location co-ordinates were recorded. Samples were sealed immediately after collection and carefully transported to ensure that their integrity would not be compromised.

Before processing of the bulk-sediment samples by Overburden Drilling Management Limited (Nepean, Ontario), a 500 g character sample is collected from each sample for archiving. The bulk-sediment samples will then be progressively reduced by a range of processing techniques to concentrate gold and base-metal indicators. Potential oxide and silicate indicators of massive-sulphide deposits will be visually identified, counted and hand-picked.

Stream-sediment samples are being air-dried at temperatures below 40°C. After drying, samples will be sieved through a minus 80 mesh (177 µm) screen. Control reference and duplicate samples will be inserted randomly into each batch of 20 samples.

Processed sediment pulps and a minus 80 mesh sample recovered from the bulk samples will be analyzed by Bureau Veritas Commodities Laboratory (Vancouver, BC) for minor and trace elements by ICP-MS following aqua-regia digestion (53 elements). Total gold determinations plus 35 elements by INAA will be provided by Maxxam Analytics, a Bureau Veritas Group company. Loss-on-ignition (LOI) will also be determined.

Pebble samples will be sorted and catalogued to provide information on the lithology of bedrock sources found upstream from the sample site.

Summary

Incorporating bulk stream-sediment sampling into government-funded regional geochemical surveys has been identified for effectively maintaining strict design requirements and program objectives while reducing overall collection costs. There are numerous opportunities to apply this survey technique in BC, including regions where RGS programs have not been conducted and areas where nominal sample-site densities may have undervalued mineral assessments or inadvertently misrepresented geochemical results.

Guided by NGR specifications, older RGS programs typically collected conventional silt-sediment samples at an average sample-site density of one site every 13 km^2. Although first- and second-order drainages were targeted, larger drainages were also sampled. Widely spaced sample sites leave large areas unrepresented. The geochemical results from samples collected at the outlet of large drainages could also be adversely affected by dilution of anomalous sediment and by complex bedrock and surficial geology that may limit the extent of element dispersal.

Figure 4. Examples of representative bulk-sediment sample sites located on **a)** the upstream end of a mid-channel bar, and **b)** a mid-channel boulder trap.

This project has been designed to demonstrate the application of this method in the ongoing development of the BC RGS database. It is expected that acquiring indicator minerals from a relatively small number of strategically located sample sites will improve overall geochemical coverage and enhance the detection and interpretation of mineral dispersion. Applying this technique to other regions of the province can further the utility of the existing RGS database as an exploration tool for the discovery of hidden mineralization, and be accomplished economically.

Results of this study are scheduled to be released in late spring 2020.

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